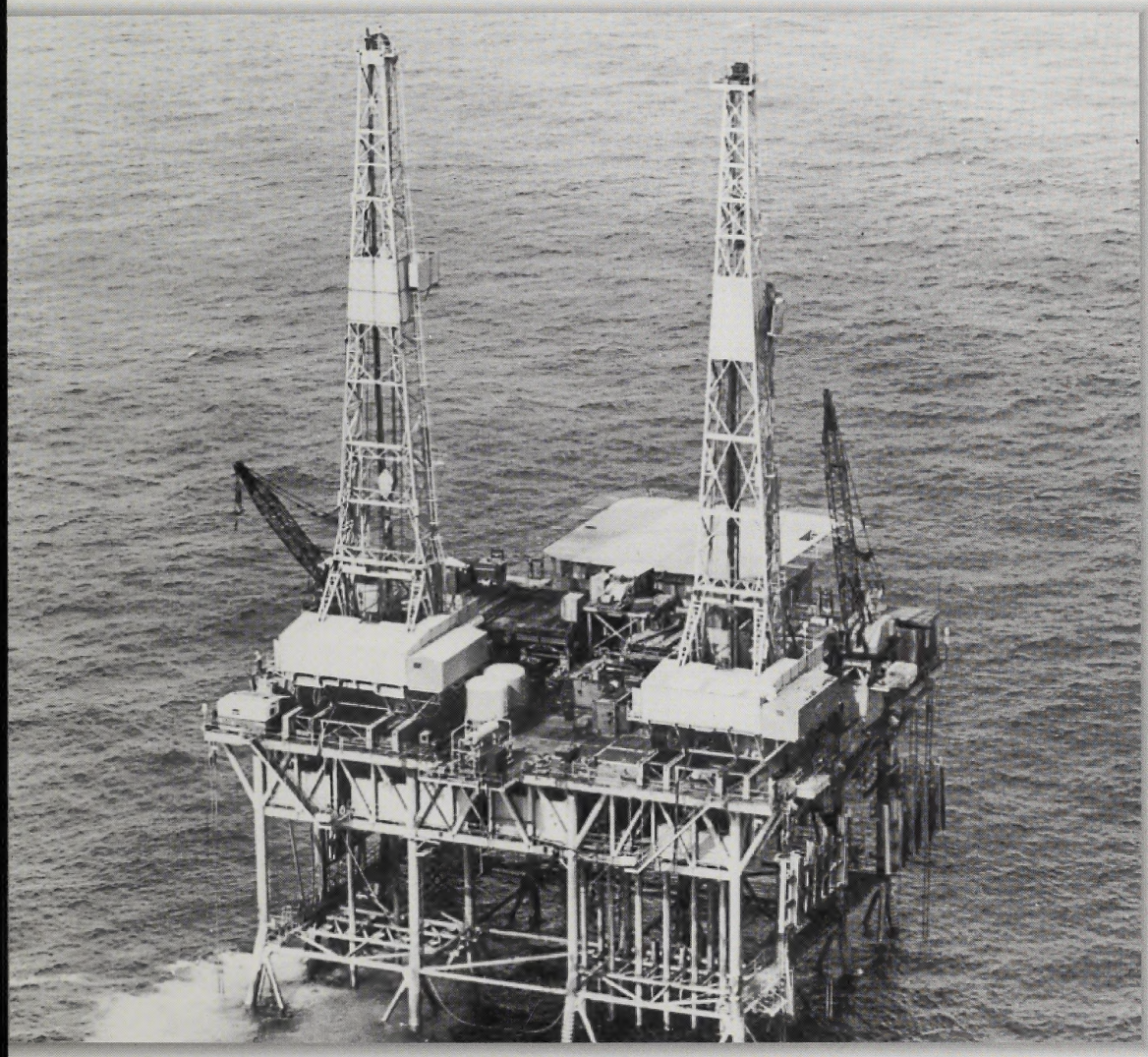
Science 30



MODULE 4

Organic Compounds and the Environment

Distance Learning

Alberta EDUCATION

Science 30

Module 4

Organic Compounds and the Environment

Alberta
EDUCATION

This document is intended for	
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Organic Compounds and the Environment
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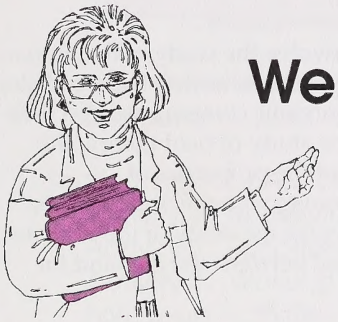


Welcome to Module 4!

We hope you'll enjoy your study of Organic Compounds and the Environment.

To make your learning a bit easier, watch the referenced videocassettes whenever you see this icon.

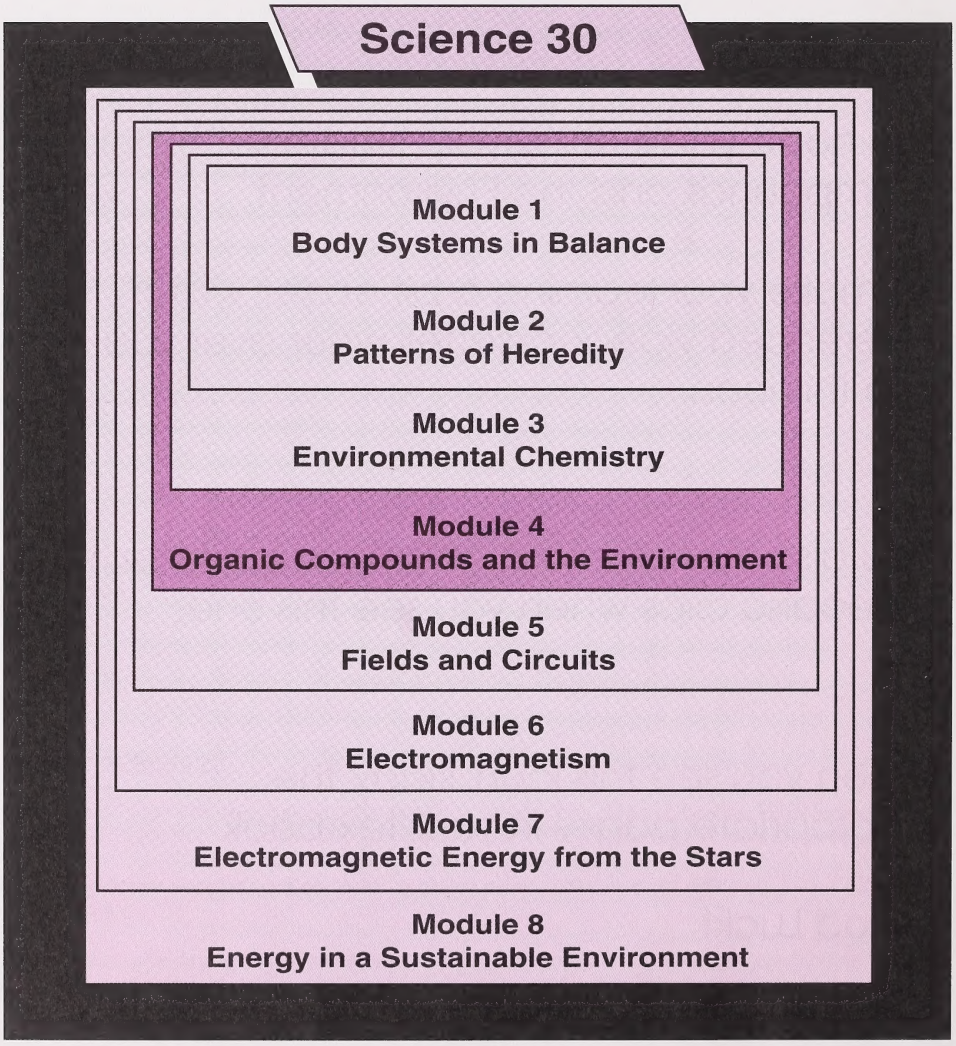
You also have the option of viewing laser videodisc clips when you see this one.

When you see this icon, study the appropriate pages in your textbook.

Good Luck!

Course Overview

This course contains eight modules. Modules 1 and 2 involve the study of the human circulatory system, defence mechanisms, the nervous system, as well as the principles of genetics. Modules 3 and 4 investigate acids and bases, organic compounds, and their effects on the environment. Modules 5 and 6 involve the study of field theory, the operation of various electrical devices, as well as some of the properties of electromagnetic waves. Module 7 focuses on the electromagnetic spectrum and its relation to the study of the Universe. Module 8 will involve the study of the various sources of energy and how a balance must be maintained between the demand for energy and the need to maintain a viable environment.



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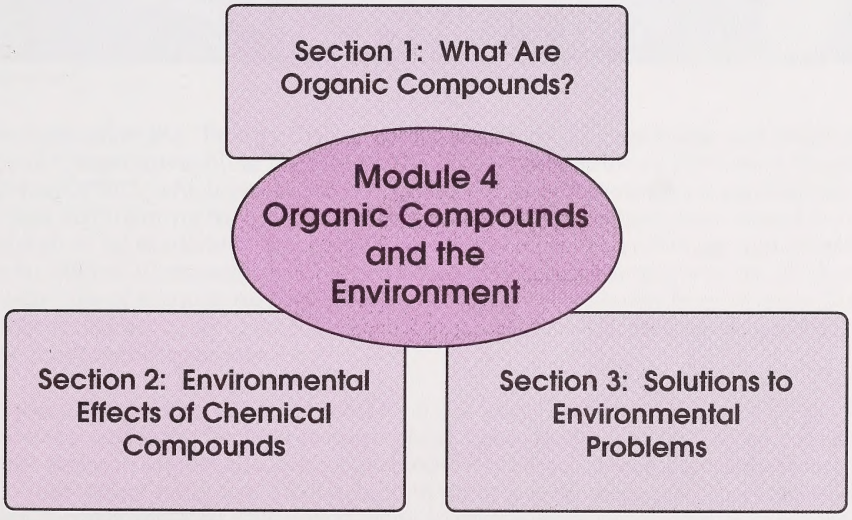
MODULE OVERVIEW

What would you say is the greatest environmental threat, on a world-wide basis, to society? Global warming due to the greenhouse effect? High incidences of destructive ultraviolet radiation because of holes in the ozone layer? Destruction of plant and fish stocks due to acid precipitation? Higher incidences of cancer due to various chemical contaminants in polychlorinated biphenyls (PCBs) or pesticides? Your answer will vary, depending on what is an environmental problem for you. In any gathering of environmentalists you can hear arguments about the effects on society for each of these issues. Each one has a destructive potential for different portions of the biosphere. Each one also has its source in the activities of human society. Automobile emissions contain greenhouse gases and contribute to acid precipitation. Refrigeration units and aerosol propellants contain chlorofluorocarbons (CFCs), which destroy the ozone when they are released into the atmosphere. PCBs, as coolants in transformers used to regulate electricity, are released into the environment during fires. The common factor is that these are all the result of the use of organic chemicals, both natural and synthetic.

In this module you will analyse the nature of what makes chemicals organic by looking at their structure and classification. You will also investigate some of the ways in which organic chemicals interact with inorganic chemicals and the environment. Lastly you will identify ways in which some of the problems created by the use, and misuse, of organic chemicals can be solved.



Evaluation

Your mark in this module will be determined by how well you complete the assignments at the end of each section. You must complete all assignments. In this module, you are expected to complete three section assignments. The mark distribution is as follows:

Section 1 Assignment	**45 marks**
Section 2 Assignment	**35 marks**
Section 3 Assignment	**20 marks**
TOTAL	**100 marks**

Section

1 What Are Organic Compounds?

WESTFILE INC.

Do you remember the "Energy Crisis," which struck the United States and much of the European Commonwealth in the late 1970s? The Organization of Petroleum Exporting Countries (OPEC), which produced 66% of the world petroleum, increased oil prices by more than 400% during the 1970s. Western oil companies in turn were forced to restrict the amount of oil marketed. The result was long lineups at gas stations and exorbitant prices for almost all manufactured goods. You may be wondering how an oil shortage affects the cost of manufactured goods. Very simply! Remember from Science 20 that oil can be transformed by chemical reactions into petrochemicals such as plastic, nylon, and other synthetic materials.

Think about the amount of plastic used by the average person in today's society. Plastic bottles, bags, and wrap for food storage; plastic parts in almost every machine; and synthetic fibres in almost all clothing and footwear are examples of plastic products used. What would happen if all of a sudden there was no more plastic! As oil and gas reserves become depleted, this will become a serious issue. Is it possible to replace oil and gas with other organic compounds?

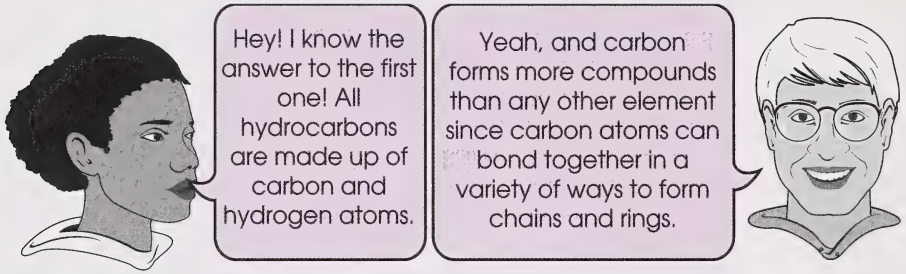
This section will reintroduce you to the nature of organic compounds. You will review how to name organic compounds and how to represent those compounds as structural diagrams. You will also learn about the importance of functional groups in classifying organic compounds.

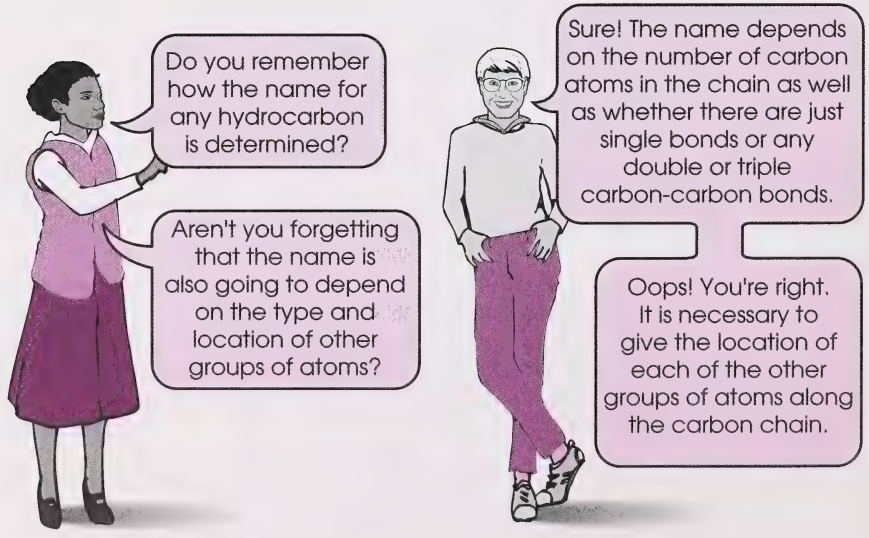
Activity 1: Reviewing Organic Compounds

In Science 20 you were introduced to a class of chemicals called hydrocarbons which form the basis of all organic compounds. You went on to study the chemical and physical properties of hydrocarbons, especially as related to petrochemicals. Based on your previous studies, you should be able to answer a few basic questions about organic compounds.

- What is a hydrocarbon?
- What exactly is an organic compound?
- How do you name organic compounds?
- How do organic compounds differ from other chemical compounds?

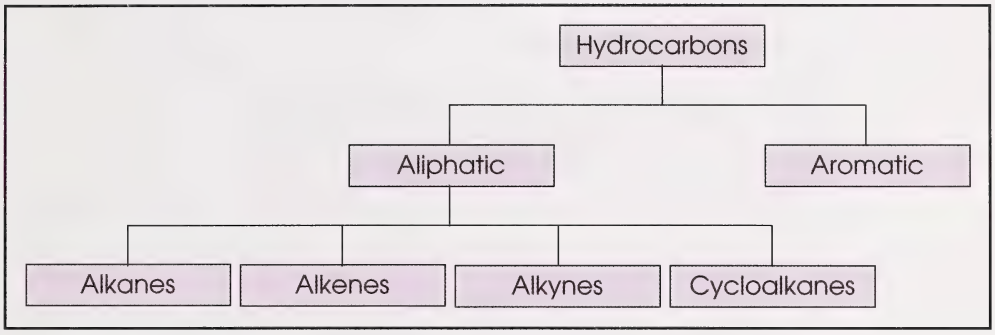
Follow along with Nicole and Mike as they recall some of the things they learned in Science 20.

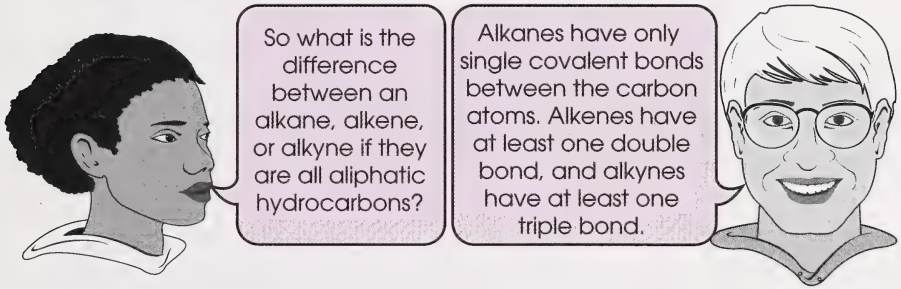


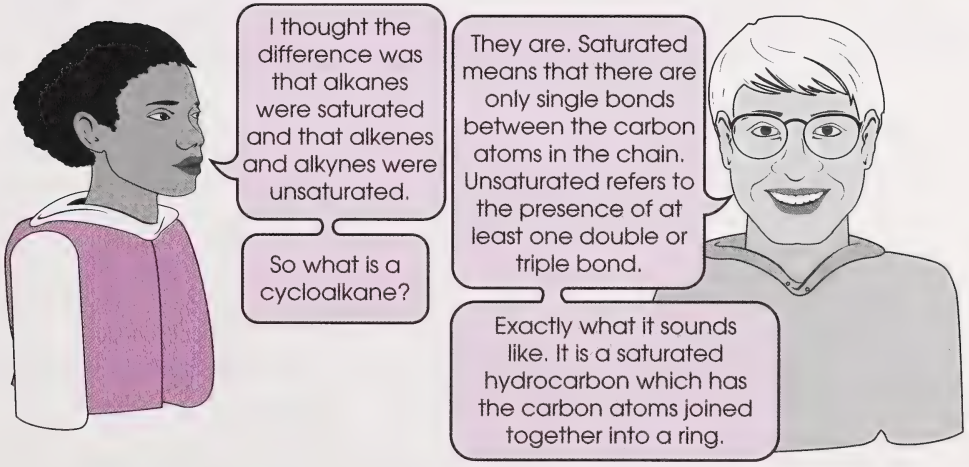


Even though hydrocarbon compounds can have quite complex structures, and hence names, it is possible to sort hydrocarbons into two basic types—aliphatics and aromatics. The difference between the two is that aromatic hydrocarbons contain one or more **benzene** rings. Aliphatic hydrocarbons don't contain any benzene rings, but they are further divided according to the number of chemical bonds found between the carbon atoms which make up that compound.

benzene – a ring of six carbon atoms which contains three double bonds spaced evenly







You may have heard the terms *unsaturated* or *polyunsaturated* in reference to cooking oils. While unsaturated compounds contain one or more double or triple bonds, polyunsaturated compounds must contain at least two double or triple bonds and usually contain several double or triple bonds. Such substances cannot be alkanes since they contain one or more double or triple bonds.

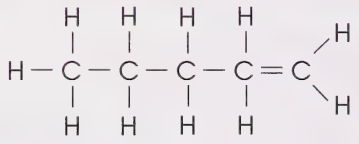
1. Given the following structural diagrams, indicate which ones represent

   a. a saturated hydrocarbon

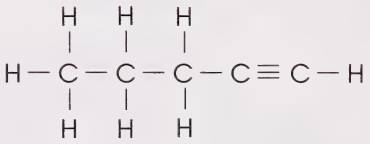
   b. an unsaturated hydrocarbon

   c. a polyunsaturated hydrocarbon

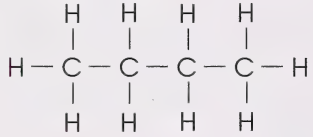
I.



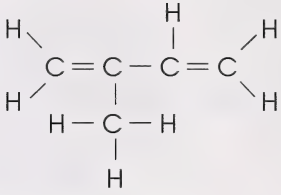
III.



II.



IV.



Check your answers by turning to the Appendix, Section 1: Activity 1.

In working with hydrocarbons and other organic molecules you will need to be able to draw structural diagrams for any given molecule exactly as you did in Science 20. You should also remember that the name for any specific hydrocarbon is determined using the IUPAC naming convention. The IUPAC system is quite extensive but can be reduced to the following set of rules. These rules will work for almost all simple hydrocarbons. If necessary, you can always look up the exact rules, but that won't be necessary for this course. Here are the rules for naming aliphatic hydrocarbons.

Rule 1: The name of the hydrocarbon refers to the number of carbon atoms in the longest chain of carbon atoms.

Rule 2: Use a prefix to indicate the number of carbon atoms present. Note: Memorize the prefix used to indicate from one to four carbon atom chains.

Number of Carbon Atoms	Prefix Used
1	meth-
2	eth-
3	prop-
4	but-

Use Greek prefixes to indicate more than four carbon atoms in a chain.

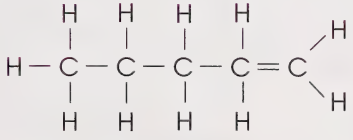
Number of Carbon Atoms	Prefix Used
5	pent-
6	hex-
7	hept-
8	oct-
9	non-
10	dec-

Rule 3: Branches attached to the longest carbon chain are named using the appropriate prefix to indicate the number of carbon atoms in the branch and adding "yl."

Rule 4: You must indicate where the side branches of the longest carbon chain occur. To do this, you number the carbon atoms of the longest chain starting from the end that has a branch closest to it.

Rule 5: If more than one side group is present, always use the name that gives the lowest numbers and indicate, if identical groups are present, the number of groups using Greek prefixes "di," "tri," and so on.

Rule 6: For alkenes and alkynes indicate where the double or triple bonds are using the lowest possible number. If more than one double or triple bond is present, use "di" or "tri" with the "ene" or "yne" ending.

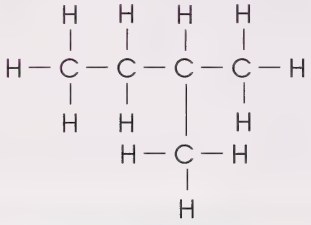


1-pentene

This example has five carbons in the longest chain so the prefix "pent" is used to describe it.

There is a double bond present, so this compound is an alkene. The suffix "ene" is used to indicate this fact.

The double bond is located on the first carbon in the chain so the number "1" is used to describe its location. You may find the number "1" omitted in some textbooks.



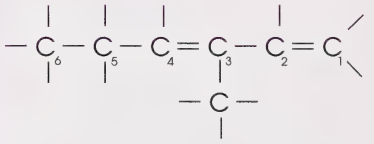
2-methylbutane

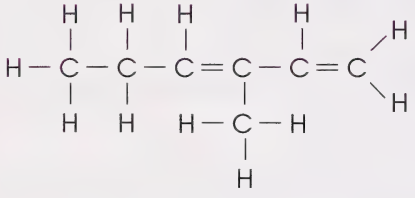
This example has four carbons in the longest chain so the prefix "but" is used to describe it.

There is no double or triple bond present so this compound is an alkane. The suffix "ane" is used to indicate this fact.

There is a "methyl" group located on the second carbon in the chain so the number "2" is used to describe its location.

The following is a slightly harder example.





3-methyl-1,3-hexadiene

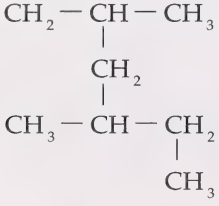
This is a hexene because it contains double bonds and the longest chain is six carbon atoms.

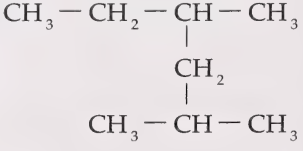
The carbons are numbered from the right since the double bonds are closest to the right side.

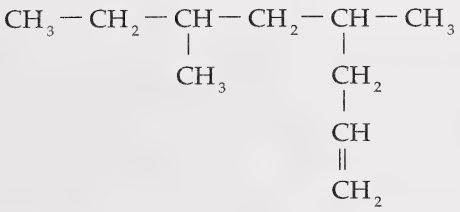
The numbers "1" and "3" are used to show the position of the double bonds.

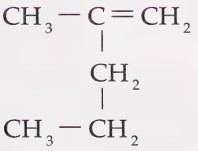
The prefex "di" is used to indicate that there are two double bonds present.

2. The key to naming hydrocarbons is the ability to identify the longest chain. Reproduce the following molecular structures on your own paper. Draw a line through the longest chain of carbon atoms and give the name which will describe that chain. Remember, the chains do not have to be in a straight line.

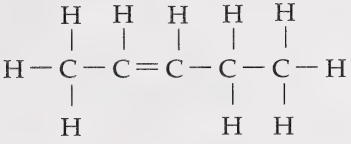
a. 

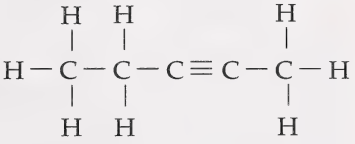
b. 

c. 

d. 

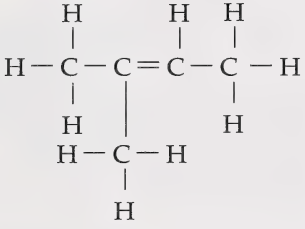
3. For the following hydrocarbons give either the name of the compound based on its molecular structure, or draw the molecular structure of the compound based on its name.

a. 

d. 

b. ethene

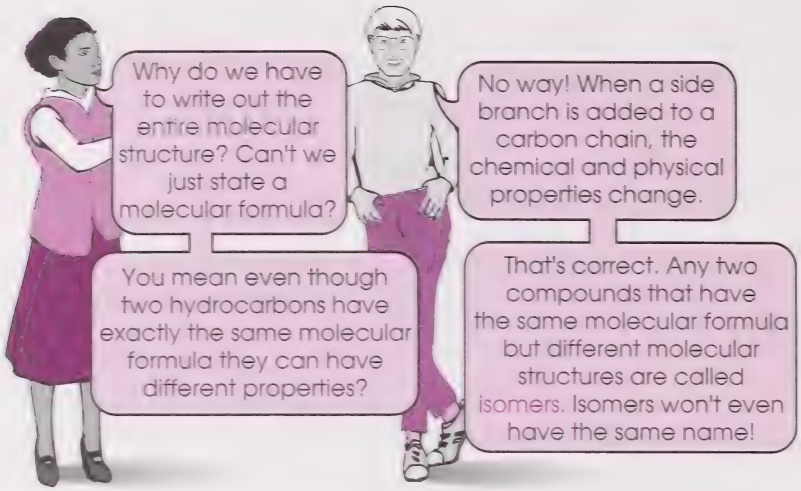
e. 3-ethylheptane

c. 

f. 2,2-dimethylpropane

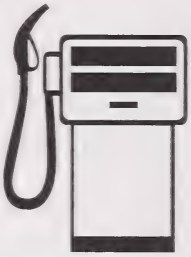
Check your answers by turning to the Appendix, Section 1: Activity 1.

Notice that the preceding questions have used either a complete structural formula as in questions 3.a., 3.c., and 3.d., or a condensed structural formula as in question 2.a. to 2.d. The molecular formula is not used when questions are asked regarding naming organic compounds. Follow the next sequence with Nicole and Mike to find out why a molecular formula such as C_8H_{18} is not used.



isomer – a compound that has the same molecular formula as another compound but a different molecular structure

This may sound really strange but it is easy to show! Consider, for example, octane. Octane is a component of the gasoline which is burned to power your car. The following are two isomers of octane. Notice that the isomers have the same molecular formula but do not have the same molecular structure. In fact they do not even have the same name! In addition, these isomers don't have the same physical properties since the boiling point of octane is higher than the boiling point of 2,2,4-trimethyl pentane. The following diagram shows the condensed structural formula for each of these two isomers.



$CH_3-CH_2-CH_2-CH_2-CH_2-CH_2-CH_2-CH_3$

octane

molecular formula C_8H_{18}

$$CH_3-\underset{\displaystyle CH_3}{\overset{\displaystyle CH_3}{\overset{|}{\underset{|}{C}}}}-CH_2-\underset{\displaystyle CH_3}{CH}-CH_3$$

2,2,4-trimethylpentane

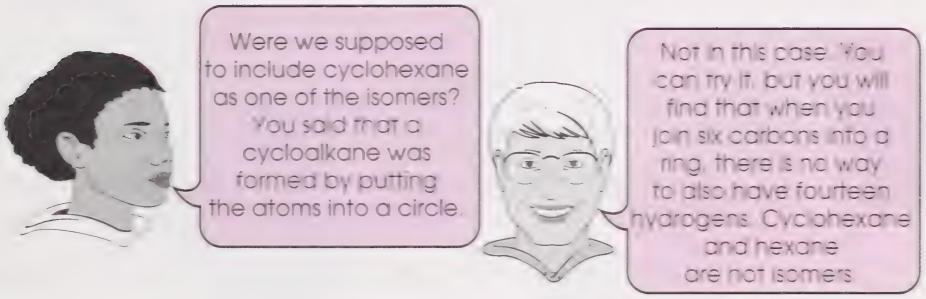
Count the number of carbon and hydrogen atoms in each of the hydrocarbons shown.

The molecular formula for any substance only indicates the number of each atom in the molecule. It does not indicate the arrangement of those atoms.

4. Hexane has the molecular formula C_6H_{14}. You should be able to determine the molecular structure for the five isomers of hexane. Write the condensed structural formula for all the isomers of hexane and give the correct IUPAC name for those isomers.

   Note: If you find it easier to work with molecular models you can easily make your own. All you need is a couple of bags of jujubes and a package of toothpicks. The ones pointed at both ends work best. Let the black jujubes be the carbon atoms and pick any other colour to be the hydrogens. Remember each black jujube must have four toothpicks stuck into it, while the "hydrogens" can only have one toothpick.

Check your answers by turning to the Appendix, Section 1: Activity 1.

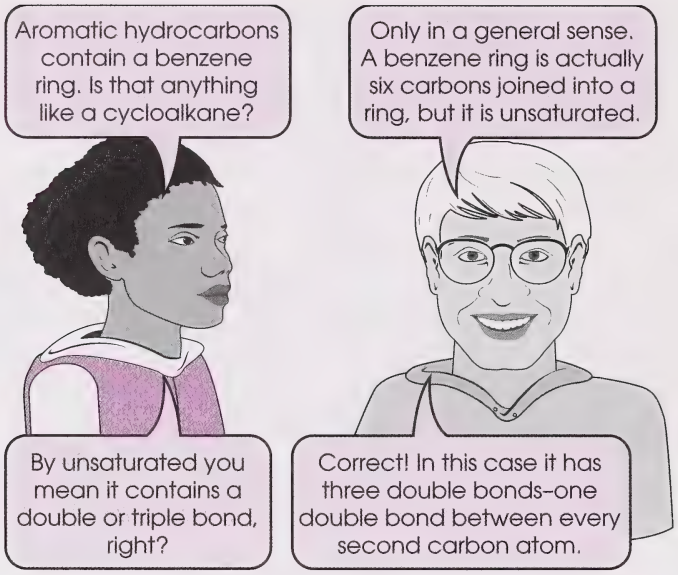


The cycloalkanes are not isomers of the alkanes. Even though the two chemical formulae will have the same number of carbon atoms, they will not have the same number of hydrogens; thus, they cannot be isomers.

5. Determine the molecular structure for cyclohexane. What is the molecular formula for cyclohexane?

Check your answers by turning to the Appendix, Section 1: Activity 1.

The cycloalkanes are important to organic chemists mostly because there are a large number of substances produced by living organisms which contain cycloalkanes. Those substances play a significant role in maintaining the homeostasis of living organisms.

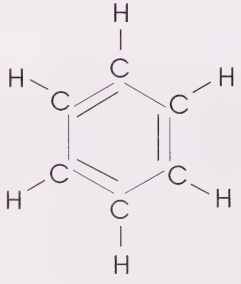


Visions

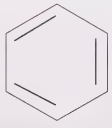
6. Knowing that a benzene ring has six carbons and three double bonds, draw the structure of a benzene ring. If you have difficulty, refer to some of the compounds that include a benzene ring on pages 203, 206, and 207 of *Visions 3*. Do you think benzene would have any isomers? Why or why not?

Check your answers by turning to the Appendix, Section 1: Activity 1.

The presence of a benzene ring in a compound makes it "smelly." The odour, however, is not necessarily always a pleasant one. Some of the more agreeable organic compounds which contain a benzene ring are those found in cinnamon and wintergreen. The following diagrams show the structure of benzene as it is often found in textbooks.



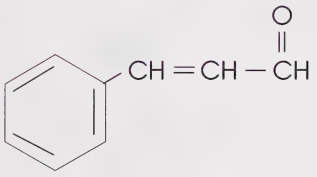
Structural model showing all bonds



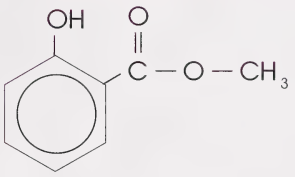
Stylized to show only carbon bonds

Stylized to show all carbon bonds for isomers

Notice the presence of the benzene ring in both the cinnamaldehyde and methyl salicylate as shown in the following structural diagrams.



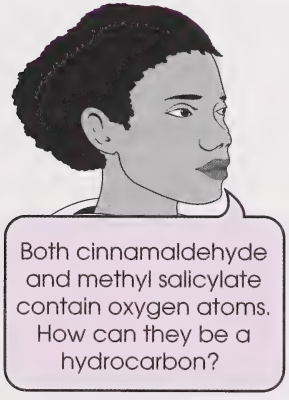
cinnamaldehyde
(found in cinnamon)

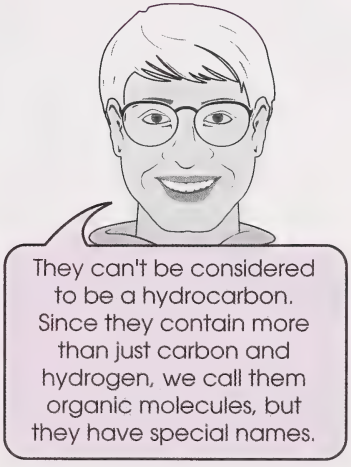


methyl salicylate
(found in oil of wintergreen)

7. How many atoms of hydrogen must be removed from cyclohexane to make it into benzene?

Check your answers by turning to the Appendix, Section 1: Activity 1.





In this activity you have reviewed the basic rules for naming hydrocarbons. Not all organic molecules are hydrocarbons as they contain oxygen as well as carbon and hydrogen. In the next activity you will identify many of these special organic molecules.

Activity 2: Functional Groups

functional group – an atom, a group of atoms, or special bond arrangement that gives a compound its physical and chemical properties

Functional groups are side groups attached to the carbon chain of an organic compound. Organic chemists have found that these functional groups play a large role in determining the chemical and physical properties of the compound. That is, they help set the boiling and melting points and also determine the way in which the compound reacts with any other molecule. Since living organisms depend on the interaction of organic compounds during the chemical reactions which occur in each and every cell, this is obviously of some importance. In addition, knowing the chemistry of a small number of functional groups will allow you to generalize that knowledge to include the chemical properties for a very large number of organic molecules.

Alcohols

One of the functional groups that you are probably most familiar with is the hydroxyl group. This group is the basis of alcohols.

The illustrations show common uses of alcohol. What does the word *alcohol* mean to you? Is all alcohol safe to drink?

For most people, the word *alcohol* means ethanol or grain alcohol, C_2H_5OH, commonly found in beverages such as beer, wine, and spirits.

While many other alcohols make up a large number of organic compounds, you will find that few are safe for human consumption. Even ethanol is a poisonous alcohol with fatal results in excessive amounts. As well, several deaths or cases of blindness occur every year in Alberta from methanol or wood alcohol, CH_3OH, consumption.

Visions

Read the section Alcohols Contain Hydroxyl Groups found on page 194 of your textbook and answer the questions that follow. Be sure to pay special attention to the diagrams that accompany the reading.

1. An older system of naming identifies substances as alcohols, using the term *alcohol*, for example, methyl alcohol or isopropyl alcohol. In the IUPAC system, a suffix is used to identify alcohols as such. What is the suffix used?

2. The preceding rules for naming organic compounds using the number of carbon atoms in the longest chain and position of functional groups still applies when naming alcohols. Look for the —OH as the functional group. Name the alcohol using the IUPAC system for each of the following structural formulae.

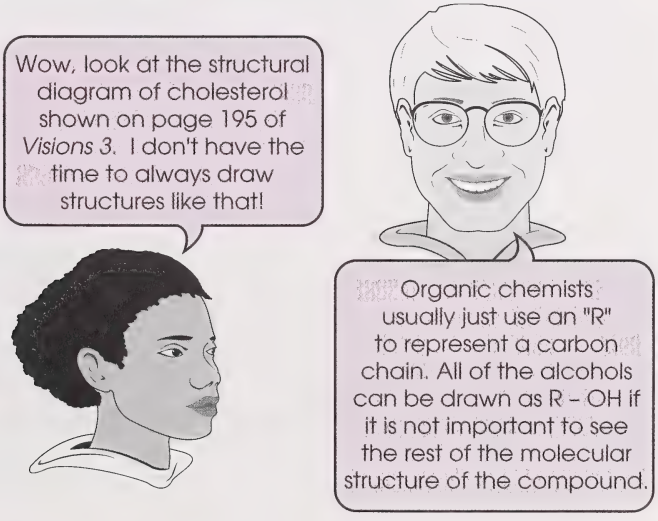
   a. $CH_3-\underset{\displaystyle OH}{\underset{|}{CH}}-CH_3$

   b. CH_3-CH_2-OH

   c. $CH_3-\underset{\displaystyle OH}{\underset{|}{CH}}-CH_2-CH_3$

   d. $CH_3-CH_2-CH_2-OH$

3. Which of the preceding compounds are isomers?



The following chart shows the general formula and structure for an alcohol and how alcohols are named.

General Formula and Structure of an Alcohol	Name Recognition
R — OH	Alcohol names have the suffix *-ol.*
Example	
$CH_3 — CH_2 —$ [OH]	ethan [ol]

4. a. What part of the compound name tells you that the substance is an alcohol?

   b. What part of the structure tells you that the compound is an alcohol?

Check your answers by turning to the Appendix, Section 1: Activity 2.

The following table gives you some examples of common alcohols and their uses.

IUPAC Name (common name in brackets)	Typical Technological Uses and Comments
a. methanol (wood alcohol or methyl hydrate)	• varnish and windshield washer solvent, gas-line antifreeze, denaturant, fuel • made at one time by heating wood shavings • highly poisonous, used to denature ethanol to prevent its consumption
b. ethanol (grain or ethyl alcohol)	• important reagent for many synthesis reactions • solvent for flavourings, perfumes, varnishes, etc. • liquor and gasoline component • made by fermenting corn, wheat, rye, potatoes, etc.
c. 1-propanol (normal propyl alcohol)	• brake fluid, lacquer, and wax solvent • starting material for many organic reactions

d. 2-propanol (isopropyl alcohol)	• rubbing alcohol • oil and gum solvent • starting material for many organic reactions
e. 2-butanol (secondary butyl alcohol)	• used to produce ketones and other organics • used as solvent, in paint removers, industrial cleaners, organic synthesis
f. 1-pentanol (pentyl)	• used in producing carboxylic acid and other organics

5. Knowing that the name of an organic compound must identify the type and location of the functional group present, draw a condensed structural diagram for each of the commonly used alcohols listed in the preceding chart.

6. Phenol (C_6H_5OH) has the more common name, carbolic acid. Phenol was widely used as a common disinfectant in hospitals, especially in the 1800s. The base for phenol is a benzene ring.

   a. Draw the structural diagram for phenol.

   b. Explain why it is not surprising to find that phenol has an odour. The odour is best described as "medicinal" or "hospital-like."

7. Alcohols, as a group, have similar chemical and physical properties. Using methanol and ethanol as a guide, what is the main industrial use of alcohols?

8. List two major advantages to adding ethanol to gasoline.

Check your answers by turning to the Appendix, Section 1: Activity 2.

Aldehydes and Ketones

Other functional groups will result in different chemical properties. The carbonyl group is also one with which you have some familiarity. You may not be familiar with the name but you are certainly familiar with the result of a compound that contains this group. Various fragrances are derived from organic compounds called aldehydes and ketones.

Have you ever wondered why some perfumes are so expensive? A wide variety of them are derived from plant sources such as exotic jungle flowers. Some sources are rare enough to make only small amounts of exclusive and therefore expensive fragrances.

Aldehydes and ketones have different properties depending on the size of the molecule or molar mass. Aldehydes with large molar masses have fragrant odours while the smaller aldehyde molecules have very sharp, pungent, and irritating odours. Do you think similar properties would apply to ketones?

Visions

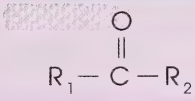
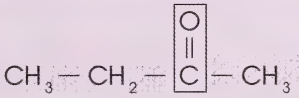
For more information on the carbonyl group, read Aldehydes and Ketones Contain Carbonyl Group on pages 194 to 196 of *Visions 3* and answer the questions that follow.

The following charts give the general formulae and structures for aldehydes and ketones, as well as how aldehydes and ketones are named.

General Formula and Structure of an Aldehyde	Name Recognition
$R(H)-\overset{\overset{O}{\|}}{C}-H$	Aldehyde names have the suffix *-al.*
Example	
$CH_3-\boxed{\overset{\overset{O}{\|}}{C}-H}$	ethan al

9. a. What part of the compound name tells you that the substance is an aldehyde?

   b. What part of the structure tells you that the compound is an aldehyde?

General Formula and Structure of a Ketone	Name Recognition
	Ketone names have an *-one* ending.
Example	
	2-butan one (ethylmethylketone)

10. a. What part of the compound name tells you that the substance is a ketone?

    b. What part of the structure tells you that the compound is a ketone?

11. How do ketones differ from aldehydes in terms of the structural formula?

Check your answers by turning to the Appendix, Section 1: Activity 2.

The following table illustrates several examples of aldehydes. Study the information.

IUPAC Name (common name in brackets)	Typical Technological Uses and Comments
a. methanal (formaldehyde)	• sharp, irritating odour • discontinued preservative for biological specimens • used to produce urea formaldehyde foam insulation, Bakelite® plastic

b. ethanal (acetaldehyde)	• cause of alcohol hangover symptoms • starting material for making many organics, industrial solvent
c. propanal (propionaldehyde)	• special solvent and intermediate in making printing inks for plastics
d. butanal (butyraldehyde)	• prolongs life of rubber products • used in producing dyes, ethers, alcohols, synthetic resins, plasticizers

12. Draw a condensed structural diagram for each of the aldehydes listed in the preceding chart.

Check your answers by turning to the Appendix, Section 1: Activity 2.

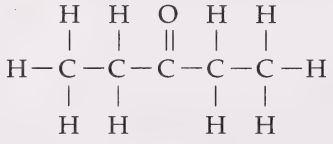
The simplest ketone is propanone, CH_3COCH_3, also known as acetone. It is found in finger nail polish remover, plastic glues, resins, and varnish.

DID YOU KNOW?

Propanone, CH_3COCH_3 is widely used as a universal solvent for organic compounds comparable to water for inorganic compounds. North American use exceeds one million tonnes annually.

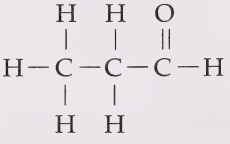
13. Give the name or draw the condensed structural diagram as required for each of the following.

a.



b. 2-propanone

c.



d. 5-methylhexanal

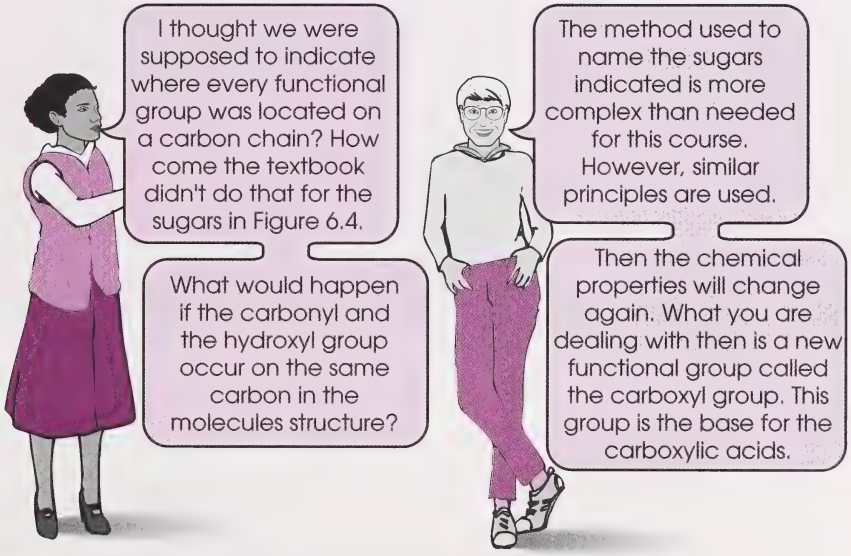
14. "Sick building syndrome" is now classified as an environmental illness. Release of toxic gases from a variety of synthetic products in airtight buildings results in a range of physical and neurological ailments for people sensitive to those toxins. What aldehyde is likely to be responsible for making people ill?

Check your answers by turning to the Appendix, Section 1: Activity 2.

DID YOU KNOW?

Muscone, an expensive perfume ingredient, is obtained from the scent glands of the male musk deer. Testosterone, a male sex hormone, is another example of a ketone.

If you have access to the laser videodisc *Cosmic Chemistry*, find and view the sequence frames 7838–12104, chapter 8, side 2. This sequence shows acetone as a solvent with polystyrene. It gives you an example of one of the properties of ketones.

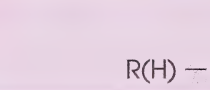
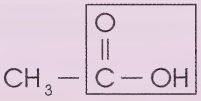


Carboxyl Acids

Visions

Turn to your textbook and read Organic Acids Have Carboxyl Groups that appears on page 196 and 199 of your textbook. Be sure to pay special attention to the diagrams that accompany the reading.

The following chart shows the carboxyl group and how carboxyl acids are named.

General Formula and Structure of Organic Acids	Name Recognition
	Carboxylic acids have names ending in *-oic acid*.
Example	
	ethan oic acid (acetic acid)

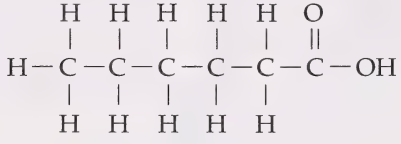
15. a. What part of the compound name tells you that the substance is carboxylic acid?

    b. What part of the structure tells you that the compound is a carboxylic acid?

16. What two functional groups do carboxylic acids contain?

Check your answers by turning to the Appendix, Section 1: Activity 2.

Historically, the simplest carboxylic acids were derived from naturally occurring fats. In a much older naming system the name for those carboxylic acids reflect where they were derived from by using Latin names. The IUPAC system uses the alkane name as the basis for the carboxylic acid name. For example, caproic acid (from the Latin word for goat, *caper*) is responsible for the smell associated with goats and Limburger cheese, but in the IUPAC system would be named as hexanoic acid.



hexanoic acid

The longest chain of carbons is six carbons. This normally would be named as hexane, without the addition of the carboxyl group.

With the carboxyl group, take the alkane name, remove the "e," and add "oic acid."

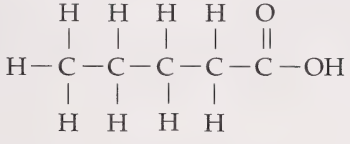
The following table gives you some other examples of carboxylic acids and their uses.

IUPAC Name (common name in brackets)	Typical Technological Uses and Comments
a. methanoic acid (formic acid)	• found in the sting of ants, bees, wasps, and nettles • food and pharmaceutical preservative • used in textile industry • used to remove hair from hides during tanning • rubber coagulant
b. ethanoic acid (acetic acid)	• main vinegar ingredient • textile dyeing mordant (fixes or sets dye colour) • industrial solvent and starting material for many organics
c. propanoic acid (propionic acid)	• used by baking industry to prevent growth of mould in bread and pastry
d. butanoic acid (butyric acid)	• putrid odour of rancid butter • used to make artificial flavours such as rum and butter, pineapple, etc.
e. pentanoic acid (valeric acid)	• blue cheese flavour
f. hexanoic acid (caproic acid)	• Limburger (cheese) and goat odour
g. benzoic acid	• used to make sodium benzoate, a common food preservative

17. Draw a condensed structural diagram for the first four carboxylic acids listed in the preceding chart.

18. Give the names of two carboxylic acids that can be found in the human body.

19. Blue cheese is a popular type of cheese. The smell of blue cheese is caused by the following organic compound. Give the name for this molecule.

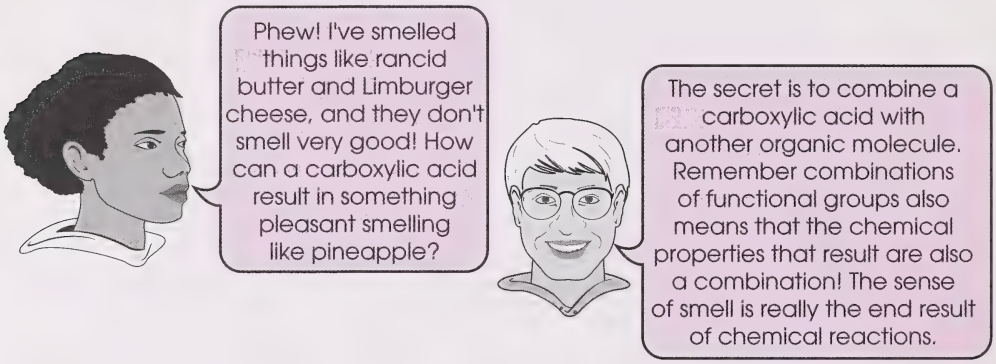


20. Propanedioic acid or malonic acid ($C_3H_4O_4$) is a dicarboxylic acid that contains three carbon atoms in a chain. The "di" prefix indicates that this compound contains two carboxyl groups. Draw the structural formula for this compound.

Check your answers by turning to the Appendix, Section 1: Activity 2.

Esters

The simple carboxylic acid, butanoic acid, results in the smell of rancid butter. The same carboxylic acid is also used to produce artificial flavourings such as pineapple.



If you performed a blindfolded taste test of different fruits, could you tell the difference between a bite of apple and a bite of cherry? You would probably tell the difference easily.

What makes a strawberry different from a raspberry, or an apricot different from a peach? Is your favourite milkshake flavour derived from natural sources or is it an imitation synthetic such as rum and butter?

Besides shapes and colours, different fruits have distinct and unique flavours and aromas. Flowers can also be identified by their unique fragrances. But did you ever stop to consider what chemicals are responsible for the taste you enjoy in a certain fruit or the aroma that identifies your favourite flower?

The chemicals that produce different flavours in fruit or fragrance in flowers belong to a class of organic compounds called esters. Esters give plants such as garlic and onion their characteristic flavours and aroma as well. Esters are a product of the reaction between alcohols and carboxylic acids, each of which you have already studied.

Visions

Read the section Alcohols and Carboxylic Acids React to Form Esters that appears on page 199 to 200 of your textbook. Pay particular attention to Figures 6.7 and 6.8.

The following chart shows the general formula and structure of esters as well as how to name esters.

General Formula and Structure of Esters	Name Recognition
$R_1(H)-\overset{\overset{O}{\|}}{C}-O-R_2$	Ester names have an *-oate* ending.
Example	
$CH_3-\overset{\overset{O}{\|}}{C}-O-CH_3$	methyl ethan oate

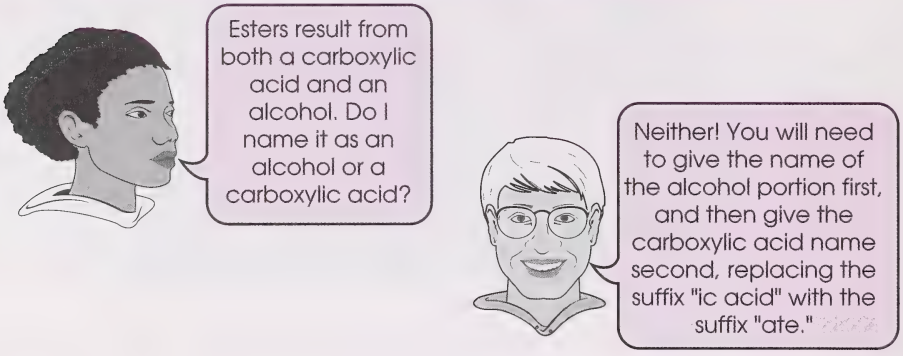
21. a. What part of the compound name tells you that the substance is an ester?

    b. What part of the structure tells you that the compound is an ester?

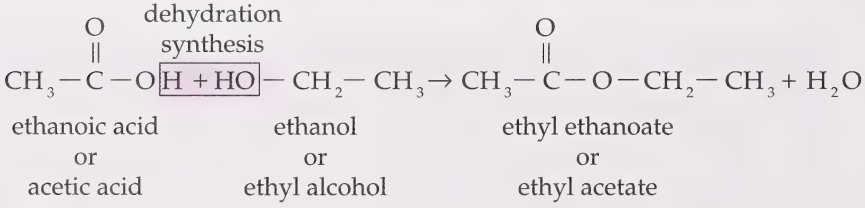
22. How do esters differ from carboxylic acids?

23. The reaction to combine an alcohol and a carboxylic acid is referred to as esterification. Knowing from Science 10 that a hydrate is a water molecule, predict why esterification can be referred to as a "dehydration synthesis."

Check your answers by turning to the Appendix, Section 1: Activity 2.



Study the following example carefully. It shows a condensation reaction called esterfication.



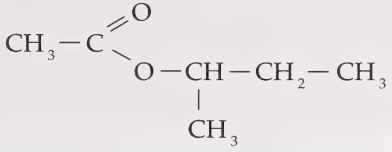
Notice that you are naming the "R" groups and also indicating the type of organic compound that gave rise to that R group. You should also notice that because ethanoic acid is usually called by its older name, acetic acid, that there will be two different names in common usage. This will only be a problem for a few of the carboxylic acids!

The following table illustrates some common esters and their uses.

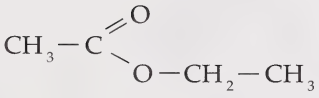
IUPAC Name (common name in brackets)	Typical Technological Uses and Comments
2-butyl ethanoate (isobutyl acetate)	• strawberry flavour
ethyl ethanoate (ethyl acetate)	• fingernail polish remover
butyl ethanoate (butyl acetate)	• raspberry flavour
2-butyl benzoate (isobutyl benzoate)	• florals and caraway flavours
2-butyl propanoate (isobutyl propionate)	• rum flavour
ethyl butanoate (ethyl butyrate)	• pineapple flavour
1-pentyl ethanoate (amyl acetate)	• pear odour
2-pentyl ethanoate (isoamyl acetate)	• banana odour • carrier for aluminum paint

24. Give the IUPAC and common name for the following esters.

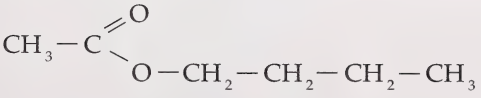
a.



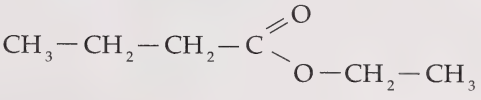
b.



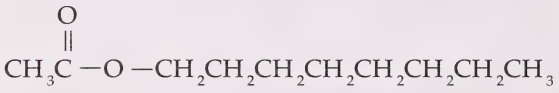
c.



d.

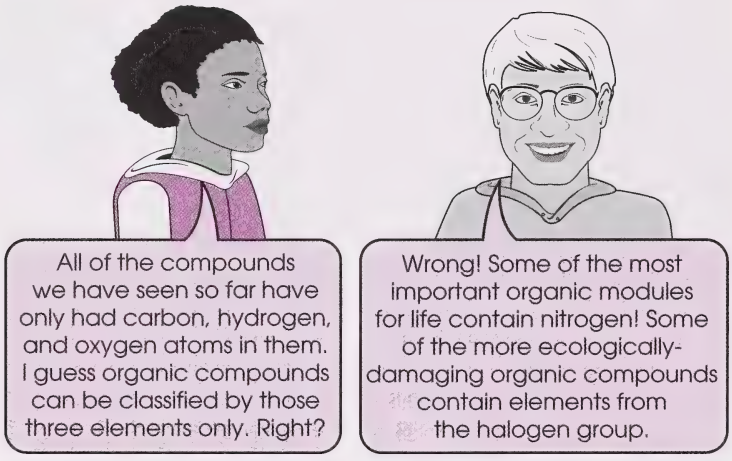


25. The following ester is responsible for the fragrance of oranges. Write its name.

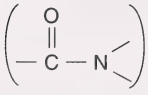


Check your answers by turning to the Appendix, Section 1: Activity 2.

Perfumes are often made of low-mass esters obtained from flowers. If you have access to the laser videodisc *Cosmic Chemistry*, find and view the sequence frames 31048–36340, chapter 22, side 6. This sequence looks at the production of perfume from the initial ester extraction to the creation of scents.

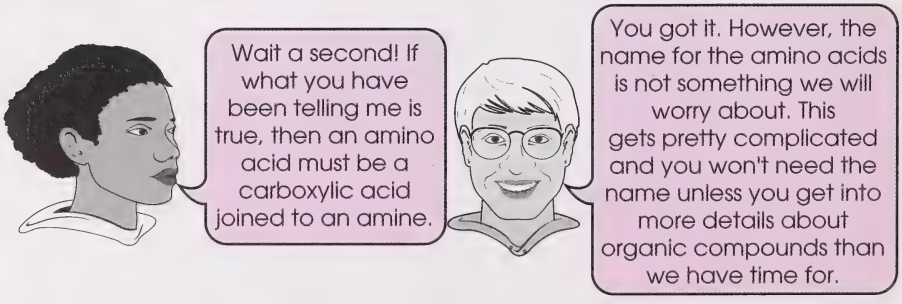


amide – an organic compound that contains the amide functional group



amine – an organic compound that contains the amine functional group ($-NH_2$)

Properly speaking, organic compounds that contain nitrogen fall into two groups—the **amides** and **amines**. Although both groups result from a reaction with ammonia, an amide is the combination of a carboxylic acid and ammonia, whereas an amine is the result of combining ammonia with one or more hydrocarbons.



Amides are named for the carboxylic acid that was reacted with ammonia to form the amide. The joining of the ammonia with the carboxyl group results in a new functional group called the amide group. This group is especially important to living organisms since it is the amide group that links amino acids together to make proteins! Remember how important proteins are for life and you will see why this is such an important functional group. Since amides and amines are quite complex, you will not cover these compounds in any greater detail in this course.

Organic Halides

The final group of hydrocarbon derivatives that you are going to study are the organic halides. Organic halides consist of hydrocarbons in which one or more of the hydrogen atoms has been replaced by a halogen atom. Halogen atoms are fluorine, chlorine, bromine, or iodine. The organic halides are not the most complex hydrocarbon derivatives, but they may be the most environmentally destructive.

DID YOU KNOW?

Medical research indicates that exposure to sunlight increases the risk of skin cancer. In 1935, 1 out of 1500 people developed skin cancer. By the year 2000 it is predicted that 1 out of 124 people will contract the disease. The only comfort in these alarming statistics is that the cure rate is about 95% when treated promptly.

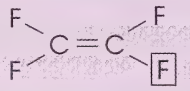
The tan you are looking for may look healthy now but you could end up paying for it down the road. You could develop skin cancer or destroy the body's ability to fight off disease or infections. What is the cause for such alarming statistics?

Evidence suggests that large quantities of chlorofluorocarbons (CFCs) and other chemicals that have been introduced into the Earth's atmosphere in recent years are destroying much of the ozone, O_3, layer. Chlorofluorocarbons are in a class of hydrocarbon derivatives called organic halides. These compounds serve various uses required by society, but many must be handled with care.

I think I can guess how organic halides are named! All you have to do is give the name of the longest chain of carbons and the names and location of all halogens present.

Sure, and for those compounds where there is more than one halogen on the same carbon or multiple bond, you will need to use a prefix to indicate how many and where they are as well.

The following chart shows the general formula and structure for organic halides, as well as how these compounds are named.

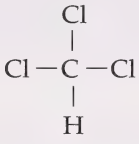
General Formula and Structure	Name Recognition
R —X where X is any halogen (F, Cl, Br, or I)	Organic halide names contain the prefixes *fluoro-*, *chloro-*, *bromo-*, or *iodo-*.
Example	
	tetra fluoro ethene (monomer of Teflon)

26. a. What part of the compound name tells you that the substance is an organic halide?

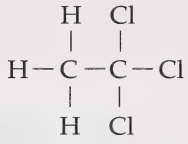
    b. What part of the structure tells you that the compound is an organic halide?

Check your answers by turning to the Appendix, Section 1: Activity 2.

The condensed structural formula for two common organic halides, trichloromethane (chloroform) and 1,1,1-trichloroethane (a water repellant), are as follows:



trichloromethane



1,1,1-trichloroethane

Note that in trichloromethane the hydrogen atom could have been in any one of the other three positions. Also, in 1,1,1-trichloroethane the chlorine atoms could have all been on the left carbon atom.

The following table lists several organic halides and their uses.

IUPAC Name (common name in brackets)	Typical Technological Uses and Comments
trichloromethane (chloroform)	• discontinued anaesthetic
tetrachloromethane (carbon tetrachloride)	• discontinued fire extinguisher, solvent
triiodomethane (iodoform)	• antiseptic
chloroethene (vinyl chloride)	• PVC plastic monomer
dichloromethane (methylene chloride)	• paint remover
1,4-dichlorobenzene (p-dichlorobenzene or paramoth)	• moth repellent, solid bathroom deodorizer
1,2-dichloroethane	• dry-cleaning solvent
1,1-dichloro-1,2,2,2-tetrafluorethane (Freon 114)	• refrigerant for air conditioners and refrigerators
2-bromo-2-chloro-1,1,1-trifluoroethane	• anaesthetic
1,1,1-trichloroethane	• Scotchgard$_{TM}$ water repellent

Visions

Read Halogenated Hydrocarbons Contain Fluorine, Chlorine, Bromine, and Iodine found on page 201 of your text and answer the questions that follow.

27. What is thought to be the most common halogenated hydrocarbon in use today?

28. Tetrachloromethane, $CCl_{4\,(l)}$ (carbon tetrachloride), was a common dry-cleaning solvent. Why has its use been discontinued?

29. How are organic halides named when there is more than one halogen atom present? Study the IUPAC names in the preceding chart to help you answer this question.

30. Draw the molecular structures for the following compounds.

    a. dichlorodifluromethane (a refrigerant, and chemical used in making styrofoam)

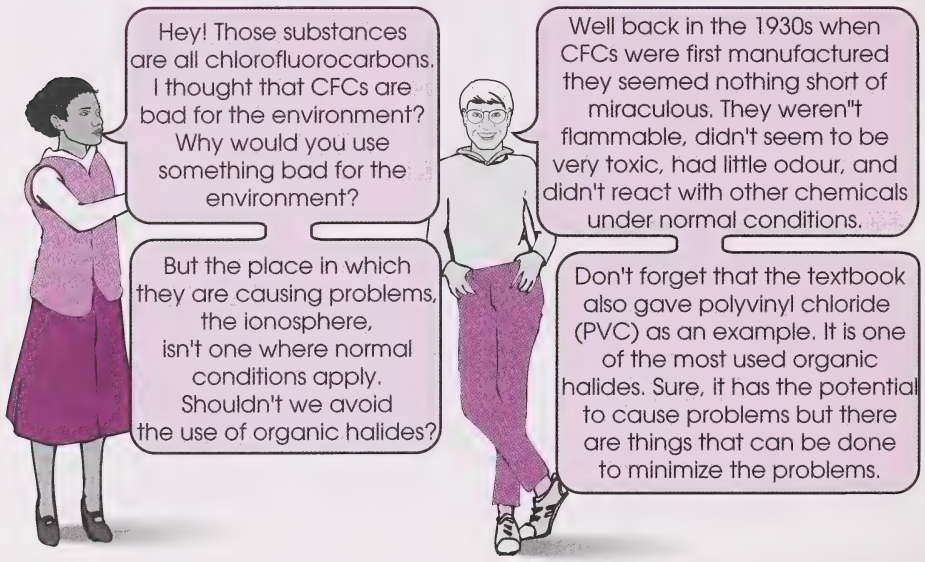
    b. bromochlorodifluoromethane (a fire suppressor in fire extinguishers)

c. 1,2-dichloroethane (used as a solvent in dry cleaning)

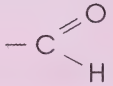
d. trichlorofluroemethane (a refrigerant, and chemical used in making styrofoam)

31. A common organic halide which is playing havoc with the ozone layer is the refrigerant 1,1-dichloro-1,2,2,2-tetrafluorethane or Freon as it is commonly known. Draw the structure of this organic halide.

Check your answers by turning to the Appendix, Section 1: Activity 2.



The following table summarizes the information about the various functional groups you covered in this section.

Class of Compounds	Functional Group	General Structure
Alcohols	— OH	R — OH, where R is a hydrocarbon residue and OH is the hydroxyl group
Aldehydes		 or RCHO where the carbonyl group, C = O, is on the terminal carbon atom of a hydrocarbon chain, R

Ketones	$-\overset{\overset{O}{\|}}{C}-$	$R_1-\overset{\overset{O}{\|}}{C}-R_2$ or R_1COR_2 where the carbonyl group, C = O, is between two different hydrocarbon chains R_1 and R_2
Carboxylic acids	$-\overset{\overset{O}{\|}}{C}-OH$	$R(H)-\overset{\overset{O}{\|}}{C}-OH$ or RCOOH
Esters	$-\overset{\overset{O}{\|}}{C}-O-$	$R_1(H)-\overset{\overset{O}{\|}}{C}-O-R_2$ or R_1COOR_2
Organic halides	F, Cl, Br, or I	R — X, where R is a hydrocarbon residue and X is a halogen

Actually it isn't really the toxicity of the organic halides that is an issue, at least on a global level. It is the fact that the organic halides are normally very stable molecules that actually create the most serious problems, but you will do more with that in the next section. First it is necessary to look at how substances such as polyvinyl chloride are produced.

In this activity you have identified a large number of organic compounds called hydrocarbon derivatives. In the next activity you will analyse some of the products produced from some of these chemicals.

Activity 3: Working with Organic Compounds

polymer – a large organic molecule formed by the linking of a large number of smaller, identical molecules

Polyvinyl chloride is what is known to organic chemists as a **polymer**. Do you remember what polymers are from your study of Science 20? Polymers come in two forms—naturally occurring and synthetic. You are familiar with naturally occurring polymers although you may not realize it just yet. For example, common substances which are polymers include the proteins in your body and the cellulose in the paper you are looking at. Natural polymers also include silk, wool, and cotton. You are also quite familiar with synthetic polymers. Nylon is a good example, or the plastic sandwich bag in your lunch. In fact all of the plastics you see around you are synthetic polymers! So exactly what is a polymer?

The word *polymer* comes from a combination of Greek words that mean "many parts." This turns out to be a very workable definition. You might recall that proteins are chains of amino acids, each amino acid linked to the next by an amide group. Protein is a polymer because it has individual units—the amino acids—joined together to form a larger molecule.

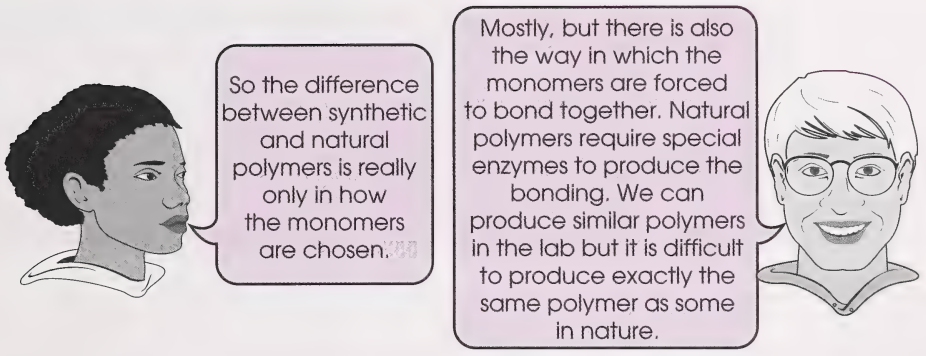
Polymers, then, are merely large molecules formed by the linking together of a huge number of smaller molecules referred to as **monomers**. Consider the following examples.

monomer – a molecule that can be linked to an identical molecule to form a long chain

MONOMER		POLYMER	
Structural Formula	**Name**	**Name and Formula**	**Use**
$H_2C=CH_2$	ethene (ethylene)	$-(H_2C-CH_2)-_n$ polyethylene	plastic bags, pipes, insulation, etc.
$HC=CH_2$ with CH_3	propene (propylene)	$-(HC-CH_2)-_n$ with CH_3 polypropylene	insulated clothing, carpets, laboratory apparatus, crates, etc.
$HC=CH_2$ with Cl	chloroethene (vinyl chloride)	$-(HC-CH_2)-_n$ with Cl polyvinyl chloride (PVC)	plastic pipes, tiles, toys, plastic rain coats, etc.
$HC=CH_2$ with benzene ring	vinyl benzene (styrene)	$-(HC-CH_2)-_n$ with benzene ring polystyrene	thermal insulation, containers, etc.

1. Teflon, a non-stick coating for frying and baking utensils, is a polymer formed from the monomer tetrafluoroethene. Draw the structural formula of the polymer.

There is no real difference between natural and synthetic polymers except for the fact that one is made by humans. There are, however, some advantages to a synthetic polymer. If you chew gum, then you have already experienced the replacement of a natural polymer with a synthetic polymer. Chicle, a rubbery polymer derived from tree sap, is now replaced with polyvinylacetate. The advantage? Your gum stays "chewable" longer! This may not seem terribly important, but the same concept was applied to other rubber products, such as valves in artificial hearts, and tires to increase the resistance to wearing out.



Visions

In many cases this hasn't even been tried. Naturally occurring polymers, such as cellulose, are very difficult to produce synthetically, but since plants do it as a normal function people can make use of that. In fact, there is probably more cellulose on this planet than any other organic molecule. Read Technology—Making Paper on pages 198 and 199 of *Visions 3*.

2. What is the name of the polymer that acts to hold the cellulose fibres together in wood?

3. Why does the chemical conversion of wood to pulp produce a better quality paper than the mechanical conversion of wood to pulp?

4. What treatment is necessary to allow the cellulose fibres to stick to each other after the lignin is removed?

Check your answers by turning to the Appendix, Section 1: Activity 3.

For more information on pulp and paper production and the chemistry of newsprint, you may wish to contact the Alberta Newsprint Company. You may also be able to arrange a tour of the facility. The address is as follows.

Alberta Newsprint Company
Postal Bag 9000
Whitecourt, Alberta
Canada T7S 1P9
Tel: (403) 778-7054

The two investigations that follow involve working with organic compounds or observing the results of working with organic compounds.

Investigation: Preparing an Ester

PATHWAYS

If you have access to laboratory facilities, do Part A. If you do not have access to laboratory facilites, do Part B.

Part A

Carefully follow the directions given for Activity 6.1 on pages 203 to 204 of your textbook. Pay special attention to the required components, safety aspects, and applied science skills.

Materials

The materials are listed in Activity 6.1 on page 203 of *Visions 3*.

Procedure

Follow the procedure given in your textbook on pages 203 and 204. Handle sulphuric acid carefully. Pay attention to the following additional precautions when doing this investigation.

- Observe caution when heating the mixture.
- Tilt the test tube away from yourself and others when heating the mixture.
- Be sure you have heated the mixture long enough and that you are swirling enough to ensure a good mixture.
- Dispose of chemicals in appropriate containers provided by your teacher.

Observations

5. Make and complete a chart with the following headings to help you gather evidence that a reaction has occurred.

Substance or Mixture	Aroma

Analysis and Interpretation

6. Answer questions 1 to 3 from the Analysis and Interpretation section on page 204 of *Visions 3* textbook.

Check your answers by turning to the Appendix, Section 1: Activity 3.

End of Part A

Science Skills
- ☐ A. Initiating
- ☐ B. Collecting
- ☑ C. Organizing
- ☑ D. Analysing
- ☐ E. Synthesizing
- ☐ F. Evaluating

Visions

Part B

Read through Activity 6.1: Preparing an Ester on pages 203 and 204 of *Visions 3*. Pay special attention to the required components, safety aspects, and applied science skills. Note the cautions presented in the Planning section on page 203.

7. Make and complete a chart with headings as in question 5 in Part A of this investigation. Refer to the Appendix, Section 1, Activity 3 for information to help you fill in the aroma column for the various substances.

8. Answer questions 1 to 3 from the Analysis and Interpretation section on page 204 of your textbook.

Check your answers by turning to the Appendix, Section 1: Activity 3.

End of Part B

Saponification

Have you ever bitten into your hamburger and had ketchup, mustard, relish, and beef juices drip onto your favourite shirt or pair of jeans? How do you wash out these stains?

9. Would water alone do a good job of cleaning your clothes?

10. What do you have to add to water to clean your clothes?

Check your answers by turning to the Appendix, Section 1: Activity 3.

saponification – the production of soaps from the breakdown of esters

Soaps and detergents are organic molecules that are formed by breaking esters in a process called **saponification**. These organic molecules help water remove oily dirt from hands and clothes by using their unique molecular structure to dissolve grease (oils and fats) in the water.

In the next investigation, you will produce your own soap and discover the differences in properties between the starting reactants, fats or oils, and the finished product, soap.

Investigation: Making Soap

PATHWAYS

If you have access to laboratory facilities, do Part A. If you do not have access to laboratory facilities, do Part B.

Science Skills
- ☐ A. Initiating
- ☑ B. Collecting
- ☑ C. Organizing
- ☑ D. Analysing
- ☐ E. Synthesizing
- ☐ F. Evaluating

Part A

Carefully follow the directions given for the investigation. Pay special attention to the required components, safety aspects, and applied science skills.

It is recommended that anyone who does Part A should also do Part B to gain a further understanding of soaps and detergents.

Caution: The solution of 3.5 mol/L $NaOH_{(aq)}$ is very caustic. Wear goggles and an apron to protect your eyes and clothing. If you spill any $NaOH_{(aq)}$ on your skin, wash with water immediately.

Materials

- clean fat (beef, pork, or lamb fat **or** this can be lard from the supermarket)
- 3.5 mol/L $NaOH_{(aq)}$ solution
- 250 mL beaker
- 100 mL graduated cylinder
- glass stirring rod
- 2 milk carton bottoms with 2 cm high walls from 250 mL, 500 mL, or 1 L milk cartons
- hot plate
- thermometer

Procedure

Step 1: Measure 50 g of clean fat and place it in a 250 mL beaker.

Step 2: Place the beaker on the hot plate and slowly melt the fat. Stir constantly. (**Note:** A temperature of 50°C is adequate or you may burn the fat.)

Step 3: When the fat is a liquid, remove the beaker from the heat. Cool until the fat shows resistance to the stirring rod (about 30°C).

Step 4: Obtain 50 mL of 3.5 mol/L $NaOH_{(aq)}$ in a graduated cylinder.

Step 5: Very slowly and carefully pour the $NaOH_{(aq)}$ into the beaker containing the liquid fat. Stir constantly; rapid stirring may be needed to blend the components. Be carefully when stirring—this reaction gives off heat.

Step 6: Continue to stir until the mixture has stiffened to a honey-like consistency, about 10 to 20 minutes.

Step 7: Pour the mixture into the milk carton bottoms. Cover the soap and allow it to stand for 24 hours.

Step 8: After the 24 hours have passed, peel off the carton.

Note: It is recommended that the soap cures for two to three weeks before it is used.

Observations

11. Record your observations from the investigation.

Analysis and Interpretation

12. Answer the following questions as your analysis and interpretation of this investigation.

    a. How did the texture of the soap change over the 24 h?

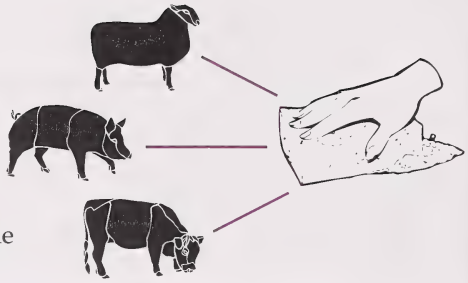
    b. Infer what causes the slippery nature of the soap.

Check your answers by turning to the Appendix, Section 1: Activity 3.

End of Part A

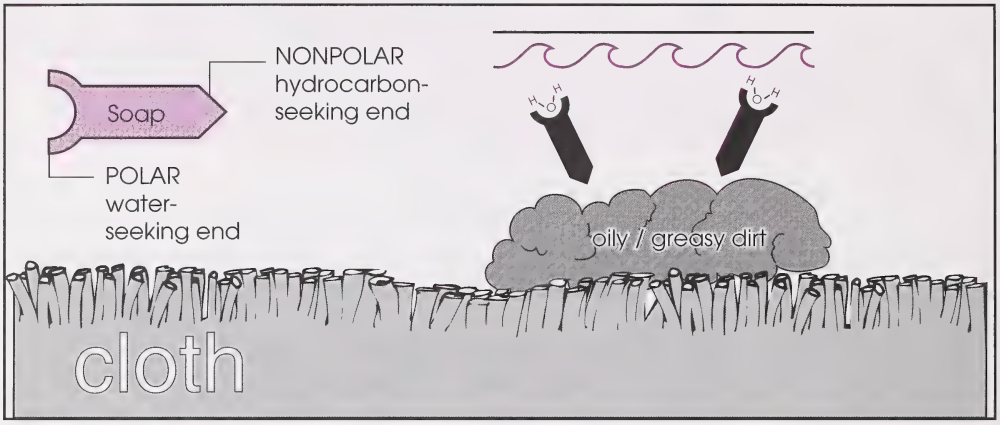
Part B

Science Skills
- [ ] A. Initiating
- [ ] B. Collecting
- [ ] C. Organizing
- [x] D. Analysing
- [ ] E. Synthesizing
- [ ] F. Evaluating



Have you ever wondered how the excess fat from the meats at your local meat market is disposed of? Tonnes and tonnes of fat are removed from slaughtered animals every day. Cattle, hogs, and sheep are the common animals butchered in Alberta; where does all the excess fat go? Is there a use for this material?

Fats may be used in the product of soaps and detergents. The following diagram illustrates the cleansing action of soaps and detergents.



View the video segment "No. 2, Soaps," from the *Organic Chemistry 2 Series* (TVO/ ACCESS Network) and answer the following questions to learn more about soaps and detergents. Read the questions before watching the video.

13. Why does a stain like "ring-around-the-collar" not dissolve easily in water?

14. What material is used to make soap?

15. Name the two types of molecules that make up a fat or oil. Provide structural formulas.

16. Describe how a soap molecule is formed. Illustrate the process using structural formulas.

17. Explain how a soap molecule dissolves grease stains. Refer to the preceding diagram for help in your explanation.

Check your answers by turning to the Appendix, Section 1: Activity 3.

End of Part B

Follow-up Activities

If you had difficulties understanding the concepts in the activities, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

Extra Help

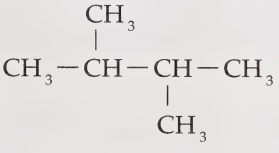
Naming compounds and drawing structural formulas is an essential part of organic chemistry. Recall the rules you learned in your previous science courses as well as the information in Activity 1 of this section as you complete questions 1 and 2.

1. The following compounds represent straight chain hydrocarbons. In other words, they are no branches to the chain. Draw structural formulas for these compounds.

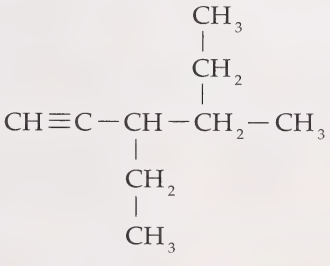
   a. C_4H_{10} b. C_2H_4 c. C_2H_2 d. C_3H_4

2. Given the following molecular structures, name the compounds indicated.

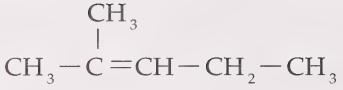
   a.



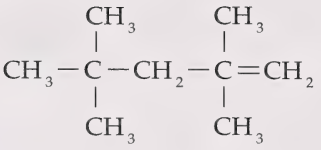
   c.



b.



d.



When given the name for a hydrocarbon, you can interpret the name using a few basic steps.

Step 1: The last part of the name indicates the longest chain of the molecule.

2,4-dimethyl-3 [-heptene] ← indicates a 7 carbon chain

Step 2: The suffix on the longest chain indicates whether there is a double or triple bond.

2,4-dimethyl [-3-] hept [ene] ← indicates a double bond

indicates location of a double bond

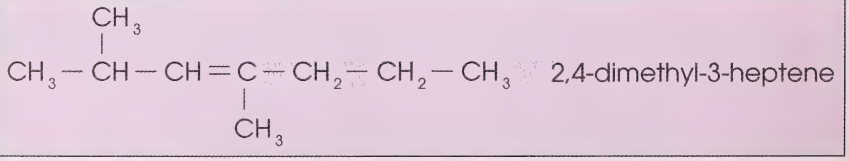
Step 3: Any side groups, and their locations, are listed first.

[2,4] - [dimethyl] -3-heptene

location of side groups

indicates type and number of side groups present

Step 4: Draw the longest chain of carbons, insert a double or triple bond if necessary into the right location, and then add in the side groups as specified.



3. Draw condensed structural formulas for the following molecules.

   a. 3-ethyl-1-pentyne

b. 3,3-diethyl-5-methyl-hexane
c. 3-ethyl-4-methyl-2-octene

An isomer is a compound that has the same molecular formula as another compound but does not have the same molecular structure.

4. Draw all possible isomers for butane.

5. Using only your five senses, what clue would you look for while investigating a compound to indicate that the compound contained a benzene ring?

6. Define the term *functional group*.

7. State one chemical or physical characteristic for each of the six functional groups you studied in this section. (Do not include the amides or amines.)

8. Complete the following chart by filling in the blanks with the appropriate name, suffix, or formula for the six groups you studied.

Class of Organic Compounds	Functional Group	Name or Suffix Used to Indicate Presence	General Formula
	— OH (hydroxyl)		R — OH
		-one	
aldehydes			
			$R_1 - C(=O) - O - R_3$
organic halides			
			$R - C(=O) - OH$

9. Do question 3 and 4 from the Checkpoint section found on page 205 of *Visions 3*.

10. What makes a polymer different from any other molecule?

11. Do textbook question 1 from page 223 of *Visions 3*.

Check your answers by turning to the Appendix, Section 1: Extra Help.

Enrichment

Do any two of the following questions.

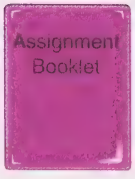
1. Answer question 2 from the Dream section found on page 225 of your textbook.
2. Using the library as a reference, write a report that discusses the production and uses of ethanol.
3. Using the library as a reference, write a report on the history of soaps.
4. Using the library as a reference, write a report on the discovery of "vulcanization" of rubber (a polymer) by Charles Goodyear in 1839.

5. If you have access to the video segment "Cosmetics" from the *Organic Chemistry 2 Series*, view the tape and write a brief summary of the procedures and decisions required to produce lipstick.

Check your answers by turning to the Appendix, Section 1: Enrichment.

Conclusion

In this section you have reviewed naming and drawing structural formulas for hydrocarbons. You have also identified a number of functional groups of organic compounds and have discovered the enormous differences in organic compounds created by the addition of these different functional groups. You finished the unit by analysing the nature and uses of polymers, both synthetic and natural. In the next section you will discover the interaction of organic compounds as related to the environment.



ASSIGNMENT

Turn to your Assignment Booklet and do the assignment for Section 1.

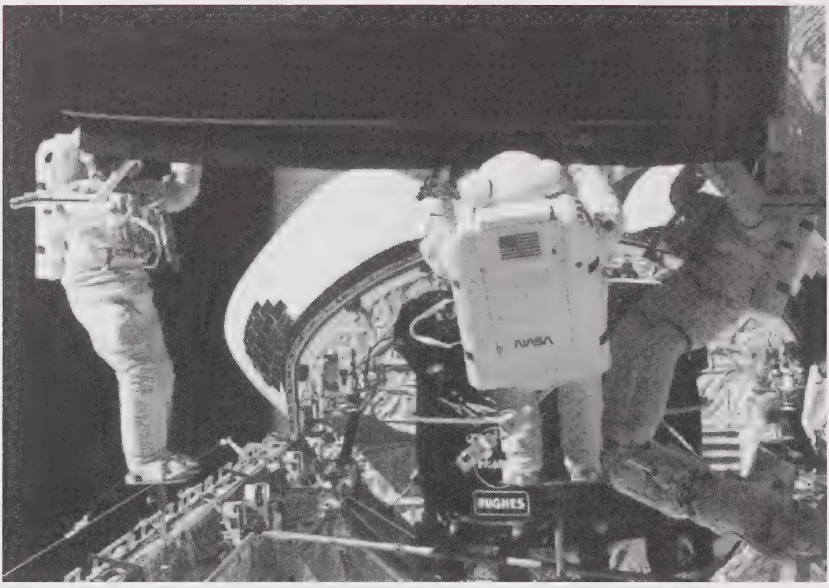
Section

2 Environmental Effects of Chemical Compounds

Have you driven a car; taken out garbage; or applied fertilizer, herbicide, or pesticide to your lawn, trees, or farm? If so, then you have added organic and inorganic compounds to the environment. Fertilizers, herbicides, pesticides, refrigerants, and plastic containers are examples of synthetically produced compounds which end up in the environment. In addition, nitrogen oxides from motor vehicles and sulphur dioxide from industry add to the number of compounds in the environment. The interaction of these various compounds with the environment is extremely complex.

In this section you will identify the advantages and disadvantages of the use of organic compounds such as pesticides, herbicides, fertilizers, and plastics. You will also analyse the effects of those substances and various inorganic compounds on the environment.

Activity 1: Synthetic Compounds—Boon or Bane



NASA

One of the things that makes human society such an evolutionary success (success being decided by how many ecological niches are occupied) is its ability to adapt to the environment. Synthetic fabrics and materials are used to construct shelters and clothing as protection from extremes of temperature, weather, and even allow for temporary visits to hostile environments such as the vacuum of space or deep ocean trenches. An increasing number of devices and tools are being constructed out of synthetic materials. Of even greater importance, in the evolutionary sense, is society's ability to modify the environment in which it lives. The development of synthetic pesticides, herbicides, and fertilizers has allowed for an increase in agricultural production and human life expectancy to levels unheard of a few decades ago!

There is, however, a downside to this development, use, and reliance on synthetic compounds. More and more often these days you hear about yet another substance found to be environmentally damaging or toxic in some way. In this activity you will focus on the specific effects of the use of synthetic organic compounds to modify the environment.

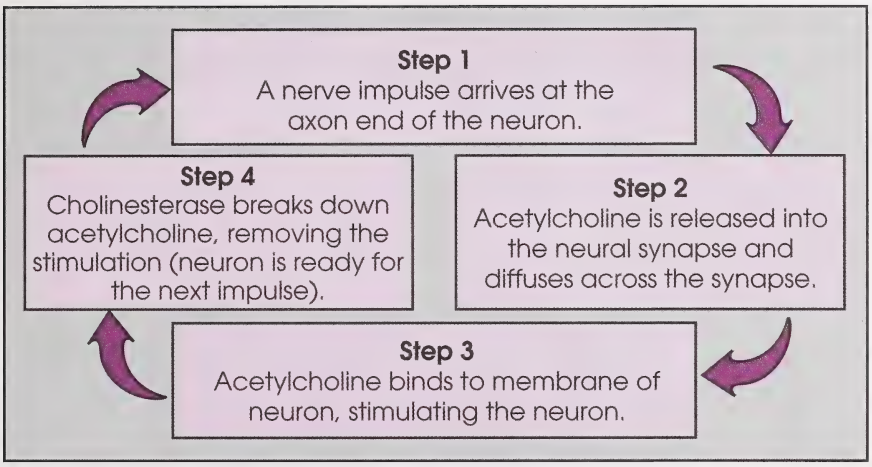
Visions

Read the Introduction on pages 192 to 193 and Are Insecticides a Necessary Risk? on pages 209 to 211 of your textbook. Then answer the following questions.

1. Halogenated hydrocarbons such as DDT are referred to as persistent pesticides. What are persistent pesticides?

2. Explain how Figure 6.14 on page 210 of *Visions 3* illustrates the process of "biological magnification."

3. With which of the following steps in the transmission of a nerve impulse does an organophosphate, or carbamates, interfere?



4. Why are carbamates and organophosphates preferable to DDT as a pesticide, even though those compounds are known to be more toxic?

Check your answers by turning to the Appendix, Section 2: Activity 1.

Insecticides have received the majority of attention in the press when it comes to environmental hazards, mostly due to the fact that the use of DDT was so prevalent. Other organic compounds are less toxic but can be much more damaging. How can a substance be less toxic but more damaging?

Visions

Read Pesticides and Organic By-products and Dioxins and Furans Are Contaminants in Several Synthetic Processes on page 205 to 207 and Lead and Mercury Are Especially Toxic When Bonded to Organic Compounds on pages 212 to 214 of your textbook. You should note that one major reason, not mentioned in your text, for organic compounds to be so damaging is the sheer volume used. Answer the following questions after you have completed the reading.

5. Herbicides should be of no danger to humans because they only interfere with chemical reactions that are specific to plants. However, as discussed on page 205 of *Visions 3*, the herbicide Agent Orange caused severe problems to humans in terms of birth defects. Explain how a substance that is non-toxic, or slightly toxic, can be such a serious hazard for humans.

6. Complete the following chart identifying the source and biological hazard of a number of organic and inorganic substances which have been released into the environment.

Substance Name	Source	Biological Hazard
		• loss of equilibrium • loss of feeling • brain damage
	toxic contaminants in PBCs produced by exposure to heat and oxygen	• birth defects • degree of harm varies with species
		• anemia • loss of kidney function • brain damage

7. TCDD (2,3,7,8-tetrachlorodibenzo-*p*-dioxin) is a known toxin which includes birth defects and cancer as side effects. Yet there is no complete agreement among scientists as to its effect on humans. Explain.

8. All of the substances in Figure 6.13 on page 210 of *Visions 3* are known to be associated with human health hazards. What is the common link between the compounds given in terms of use?

9. If mercury and lead are known to be potentially dangerous to humans, why are those substances still being used?

Check your answers by turning to the Appendix, Section 2: Activity 1.

By now you may be getting the idea that the problem with organic compounds is their toxicologic properties, but that is not always the case. In many instances, where organic compounds are actually being used to fulfil a normal role in an organism's metabolism, the problem lies with how fast and extensive that compound influences a normal metabolism.

For additional information on organic pollutants and how they can be managed view the video titled *Science, Technology and Society, Toxic Wastes*, Alberta Education, ACCESS Network, and answer the questions that follow. This video is available from the Learning Resources Distributing Centre.

10. Toxic wastes cause damage to various parts of the environment. List three types of damage caused by toxic wastes given in the video.

11. What is toxicity?

12. The video gives six general classifications for types of toxins. List three of these classifications, describe how living things are affected by each particular class, and give an example of a substance for each classification.

13. How do individuals pollute a significant amount?

14. Give one example of what is being done by industry to reduce pollution of the air.

15. What kinds of pollutants do individuals put into the environment?

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16. What can you as a consumer do to prevent these products from getting into the environment?

17. What part does the Hazardous Waste Management Plant in Swan Hills, Alberta, play in attempting to solve problems involving environmental pollution in Alberta?

18. Other than sending chemicals for disposal, what is one additional way in which you as an individual can reduce the pollution of the environment through organic chemicals?

Check your answers by turning to the Appendix, Section 2: Activity 1.

In this activity you have looked at instances in which organic compounds are intentionally added to the environment to modify it in some way. What about those cases where the environment has been unintentionally modified by the use of organic compounds?

Activity 2: NIMBY

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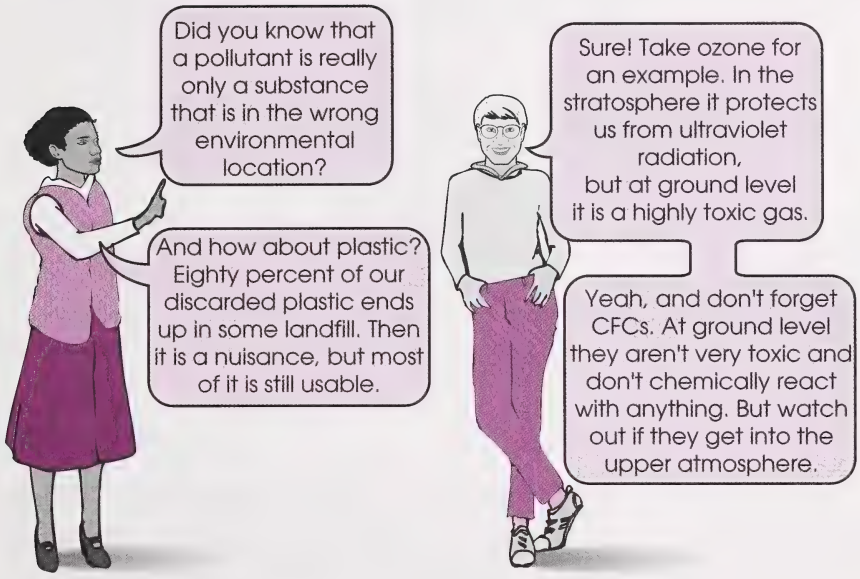
Have you ever seen the slogan "NIMBY"? Did you know that it is an acronym for the phrase "Not In My Back Yard"? The use of organic compounds has a direct relation to this phrase. Typically the use of organic compounds also entails the production of a waste product. Those waste products are usually called garbage, and garbage is almost always discarded. Here is where the problem starts. When you throw something away it always lands somewhere else in the environment and becomes the problem of someone else. In many instances the waste products produced are thought to be a local problem; however, it is becoming increasingly evident that the backyard referred to encompasses the entire globe!

In this activity you will look at some of the ways in which the waste products from the use of organic compounds is unintentionally changing the environment in which you exist. At the end of the activity you will investigate methods to test for, and treat, the presence of pollutants in water.

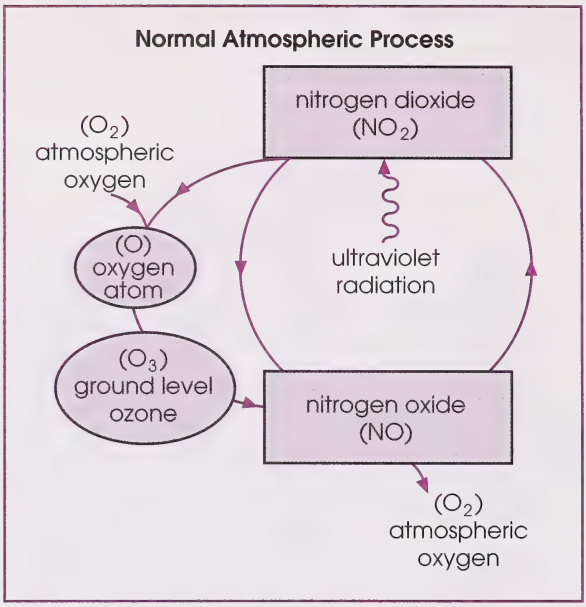


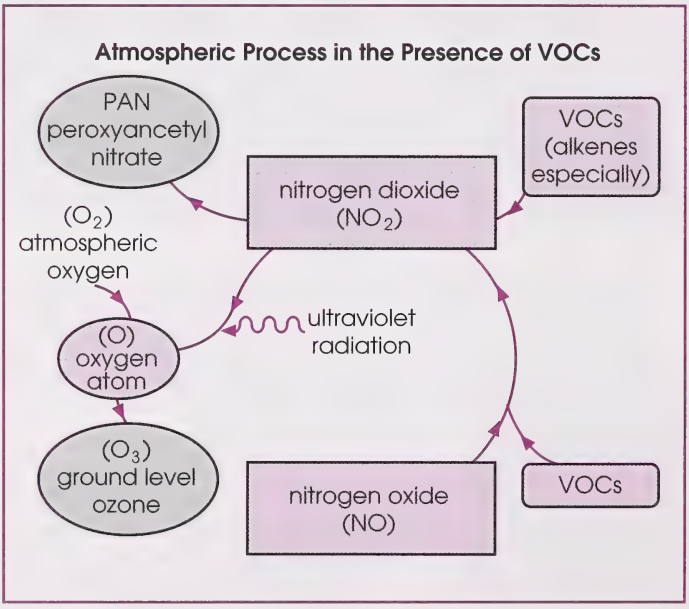
While the definition of a pollutant that was given is technically correct, it should be emphasized that a pollutant is also responsible in some way for a degradation of the environment. It doesn't matter if the pollutant is released on purpose or not. It is still a pollutant.

VOCs – organic compounds that vaporize easily or have a low vaporization point

For example, organic compounds will become pollutants by simple evaporation. Organic compounds that evaporate easily are called volatile organic compounds (VOCs). Gasoline, paint thinners, and alcohols in deodorants and hair sprays are VOCs. VOCs are even given off by trees and other plant life as well. What is worse is that VOCs, including those listed, will react in turn with other byproducts associated with the use of organic compounds.

A classic example of such a reaction is related to the burning of the organic compounds that make up fossil fuels. Internal combustion engines burn fossil fuels and the high temperatures created cause atmospheric nitrogen and oxygen gas to form nitrogen oxides. VOCs in the atmosphere react with both nitrogen monoxide and nitrogen dioxide to form two highly toxic substances. The diagrams that follow illustrate the normal atmospheric process in which there is no buildup of ozone and the atmospheric process in which VOCs react to produce peroxyacetyl nitrate and ozone.


Normal Atmospheric Process
nitrogen dioxide
(NO_2)
(O_2)
atmospheric
oxygen
(O)
oxygen
atom
ultraviolet
radiation
(O_3)
ground level
ozone
nitrogen oxide
(NO)
(O_2)
atmospheric
oxygen


Atmospheric Process in the Presence of VOCs
PAN
peroxyancetyl
nitrate
VOCs
(alkenes
especially)
nitrogen dioxide
(NO_2)
(O_2)
atmospheric
oxygen
ultraviolet
radiation
(O)
oxygen
atom
(O_3)
ground level
ozone
nitrogen oxide
(NO)
VOCs

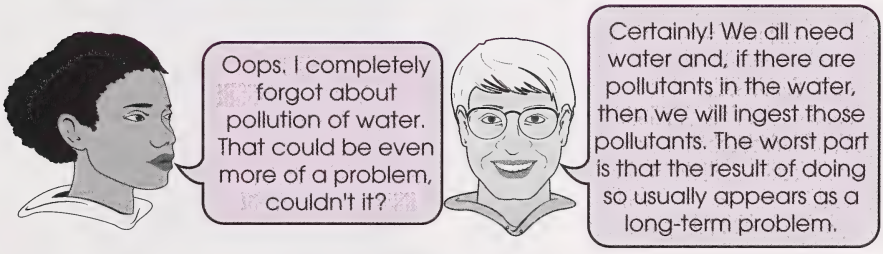
Both ozone and peroxyacetyl nitrate are known to damage leaf tissue by destroying cell walls and to reduce photosynthesis by damaging chlorophyl. The effects on humans are not well established just yet but long-term exposure to both ozone and peroxacetyl nitrate leads to irreversible changes in lung function. Both substances are also powerful oxidants (very chemically reactive) and are known to corrode synthetic polymers such as plastic and rubber. The economic cost associated with this corrosion is estimated to be at least $1 billion per year.

1. Look at the nitrogen cycle in any reference source. Explain why eliminating the use of fossil fuels is not likely to entirely eliminate the production of ground-level ozone or peroxyacetyl nitrates.

2. Disposing of old turpentine (a paint thinner) by sending it to a landfill is not a good idea since it could lead to contamination of ground water which eventually ends up as drinking water. A friend suggests leaving the turpentine to evaporate outdoors. Explain why this would not be a good solution to the problem of disposing of your turpentine.

3. Using the preceding diagrams, establish and explain how VOCs are responsible for a buildup of ozone.

Check your answers by turning to the Appendix, Section 2: Activity 2.



In Module 3 you were introduced to the ideas of dilution and concentration of dissolved chemicals. It was proposed to you that there is no such thing as "pure" water. Everything is contaminated with something else, at least to some degree. The question is to what degree is it contaminated. To answer that question it would be necessary to have some method of detection, and that has its own difficulties.

Visions

Read Environmental Chemists Sample and Analyse Water on pages 214 to 216 of your textbook to gain more information about how to detect pollutants.

4. Why are water samples taken at different levels in a lake?

5. Why is the type of container used in taking a water sample of importance?

6. List three methods used to analyse water and state what type of pollutant each is used to analyse.

The detection of organic compounds in water samples is of great importance since so many organic compounds are presently in use.

7. Research gas-liquid chromatography and write a report briefly describing how this method works.

A measurement that is of importance in water analysis is biological oxygen demand (BOD). Biological oxygen demand is the amount of dissolved oxygen needed by bacteria to decompose organic material in water. This measurement is made with an instrument similar to a pH meter except that the probe is designed to respond to oxygen instead of acidity. The measurement is made immediately after the sample is obtained and again five days later. The reduction in the amount of oxygen is the biological oxygen demand.

8. Why is the biological oxygen demand (BOD) of a water source of interest to environmental scientists?

Check your answers by turning to the Appendix, Section 2: Activity 2.

Visions

As pointed out in your textbook, although most water testing and treatment is carried out using elaborate, expensive instruments, you can do some simple analysis for the same purpose. Carefully read through Activity 6.3 which begins on page 216 of your text.

Investigation: Investigating an Environmental Issue

Read Activity 6.3 on pages 216 and 217 of *Visions 3*. Study the diagram carefully and answer the following question.

9. Develop a plan to investigate the issue presented in Activity 6.3. (If you are working on your own, complete the plan by yourself or with consultation with family or friends.)

Check your answers by turning to the Appendix, Section 2: Activity 2.

An issue that has been of great concern in recent years is that of the environmental effects of the paper production industry. Research the environmental concerns regarding the paper-making industry.

10. Write a report discussing the major causes of pollution in the paper-making industry, what the industry has done to reduce pollution in recent years, and what technological advances in the future may affect the amount of pollution created by the paper-making industry.

Check your answers by turning to the Appendix, Section 2: Activity 2.

Follow-up Activities

If you had difficulties understanding the concepts in the activities, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

Extra Help

Visions

1. Complete textbook questions 5, 6, and 7 from the Know section on page 223 of your textbook.

2. Complete textbook questions 2 and 3 from the Checkpoint section on page 214 of your textbook.

3. Complete textbook question 5 from the Think section on page 224 of your textbook.

Check your answers by turning to the Appendix, Section 2: Extra Help.

Enrichment

Do **one** of the following.

1. Using a library or other reference source, write a report summarizing your research into what some sources call "Dancing Cat Disease" which occurred in Minamata Bay in Japan in the 1950s. Be sure to include the source of this environmental catastrophe and the effects that resulted.

2. Using a library or other reference source, write a report explaining why the extensive use of pesticides is creating problems, especially in the agriculture industry.

3. Using a library or other reference source, write a report outlining the result of the use of the drug thalidomide as an anti-nausea drug in the 1950s.

Check your answers by turning to the Appendix, Section 2: Enrichment.

Conclusion

One of the major problems with the use of synthetic compounds to modify the environment, intentionally or otherwise, is that not enough is known about what those modifications will do. You established in this section that the use of organic compounds produces results that are both beneficial and disastrous. In the next section you will identify some of the ways in which the impact on the environment from the use of organic compounds can be minimized.

Assignment Booklet

ASSIGNMENT

Turn to your Assignment Booklet and do the assignment for Section 2.

Section

3 Solutions to Environmental Problems

PHOTO SEARCH LTD.

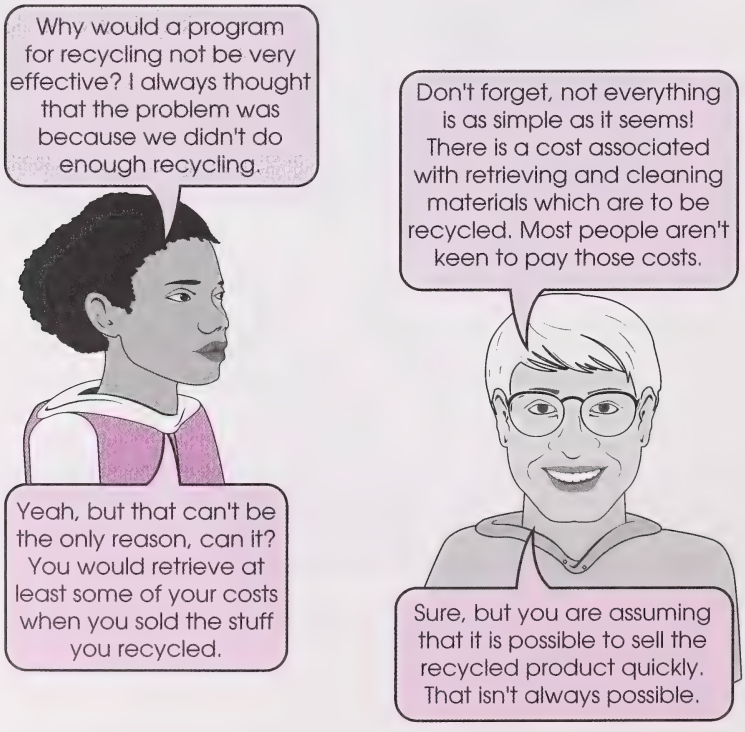
What does the name "Bhopal" mean to you? Do you remember the ghastly reports coming out of India in December 1984? A death toll of over 2000 and 200 000 injured for life resulted in just a few hours as a gas cloud released during an explosion at a chemical plant settled over the city. Do you recall hearing, more recently, of killer smog that settled over Los Angeles, Mexico City, and London? There were toxic chemical spills polluting ground water sources in Niagara Falls. The "Torrey Canyon" disaster occurred in the late 1960s. The list goes on! Yet there is an environmental catastrophe developing at this very moment that may be of an even greater magnitude. What is the name of this catastrophic problem? Garbage! To be more specific, the catastrophe lies in what to do with all of society's garbage.

In this section you will analyse ways in which the hazardous results of the use of organic compounds can be minimized.

Activity 1: Identifying a Problem

When was the last time you heard of garbage killing 2000 people? What makes garbage such a problem? You just bag it, tag it, and throw it away! Right? But where do you throw it? Remember it is just going to end up somewhere else in the environment. As a result, most municipalities end up with huge landfills and have problems finding room for more in which to store their garbage.

Garbage is anything for which there is no longer a use. Old paper and plastic from food packaging, tin cans, glass bottles, plastic bottles, old machinery, used motor oil, you name it! Surplus pesticides, herbicides, and insecticides are no longer considered to be garbage, but rather hazardous wastes. However, whether garbage or hazardous waste, there still is a problem. What should be done with it? In recent years most municipalities have initiated recycling programs to deal specifically with their garbage problems; however, the effectiveness of such programs is relatively low.



Simply put, after the recyclable materials are withdrawn from the garbage, there still are enormous quantities of materials that are not recyclable for one reason or another. Studies indicate that paper forms more than one-third of the bulk in municipal garbage collections, with glass and metals contributing 7 to 8% each. Metals and glass can be melted down and recast. Paper can be treated as pulp wood and reformed. Yard wastes (about 20%) and food waste (about 9%) are usually biodegradable. And then there are the plastics, and they are a problem!

Visions

For more information on the problem of garbage, read pages 217 to 219 in *Visions 3* and answer the following questions.

1. Look around your house for a few minutes and make a list of everything that is made of plastic or contains a plastic part.

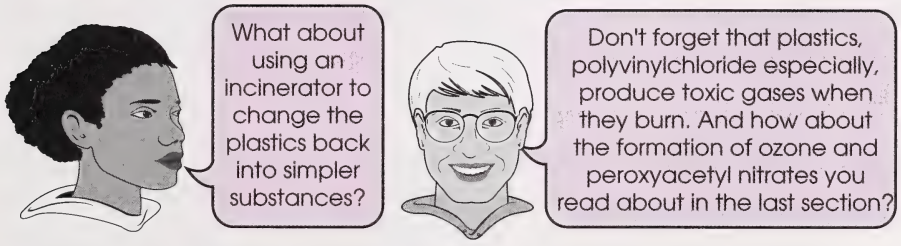
2. What was the total amount of waste buried in landfills by Edmonton and Calgary in 1992?

3. How many tonnes of residential waste were buried in the landfills by these two cities in 1992?

4. What have the consequences of burying so much garbage in landfills been for major cities?

5. Why has recycling, which has become very popular, been slow to make a significant change in the amount of garbage which is buried in landfills?

6. How are industries attempting to reduce the amount of space that plastics take up in landfills?



7. Why are plastics not eliminated by burning?

8. Identify as many other problems as you can which affect the environment.

Check your answers by turning to the Appendix, Section 3: Activity 1.

Surprisingly for all of its widespread use, plastic materials makes up only 12% of solid wastes in garbage. Although that doesn't sound like much, the amount of garbage produced is more than 100 billion kilograms of plastic waste a year! Only about 1% of that plastic waste is recycled!

Not separating the various plastics is a low-cost alternative and produces a low-grade plastic which can be formed into plastic "lumber." While this is a good start and will reduce the impact on the world's forests, plastic lumber is not suitable for the more specialized uses for which plastics are used. Presently there is not enough demand for plastic lumber to significantly reduce the quantity of plastic disposed of in landfill sites.

This has most municipalities very worried because unlike the other forms of garbage, plastics generally don't corrode and aren't biodegradable. The microorganisms that usually attack materials to decay them into simpler substances lack the enzymes necessary to disrupt the chemical bonds of synthetic polymers. As a response to this problem, plastic manufacturers have begun to add biodegradable substances such as starch and cellulose to their plastics which causes the plastic to break into small fragments and decompose. Another treatment involves adding chemicals to the plastic that break down with exposure to sunlight; however, neither treatment has been very effective thus far in reducing the amount of plastic waste proceeding to landfill sites.

Now that you have identified a number of problems involving the environment, you can look at identifying some possible solutions to these and other problems.

Activity 2: Identifying Solutions

After reading through the preceding sections and activities, does it seem to you that there is no hope for the problems of environmental degradation? One of the things which you must be prepared to face is the fact that everything has a cost, not necessarily monetary. You have identified the problems associated with the use of organic compounds and in this activity you will explore whether there is any remedy to those problems.

DID YOU KNOW?

Members of the Canadian Petroleum Products Institute have agreed to produce gasoline with lower volatility for the summer months. This gasoline will evaporate less easily and thus reduce the amount of VOCs entering the atmosphere.

The following exercise illustrates what Alberta is doing to try to solve the problems of hazardous wastes.

PATHWAYS

If you have access to the video titled *Hazardous Waste Management: Alberta's Success Story*, Alberta Special Waste Management Corporation, do Part A. If you do not have access to the video, do Part B.

Part A

Watch the video, *Hazardous Waste Management: Alberta's Success Story*, and answer the following questions.

1. What are the four *R's* of recycling?
2. Why is the Alberta Waste Management Plant required even if there is a strict policy involving the four *R's* of recycling?
3. What two wastes does the Alberta Waste Management Plant not handle?
4. How are chemicals handled to improve safety during transportation?
5. How is ground water in the area of the plant protected?
6. What is the largest group of chemicals treated?

7. What method of treatment is used for organic compounds?

8. What is being done to maintain a clean environment around the Alberta Hazardous Waste Management Plant?

Check your answers by turning to the Appendix, Section 3: Activity 2.

End of Part A

Part B

Carefully read Technology: Hazardous Waste Disposal on page 218 of your textbook. Pay particular attention to the methods being used to treat hazardous wastes and the alternatives to the use of hazardous chemicals in the first place.

9. What efforts and initiatives have been undertaken by the government to reduce the risk associated with hazardous chemicals?

10. What two wastes does the Alberta Waste Management Plant at Swan Hills not handle?

11. Describe the process used in the Alberta Special Waste Treatment Centre for the treatment of organic wastes.

12. What is done with the waste materials from the Alberta Special Waste Treatment Centre after they have been treated?

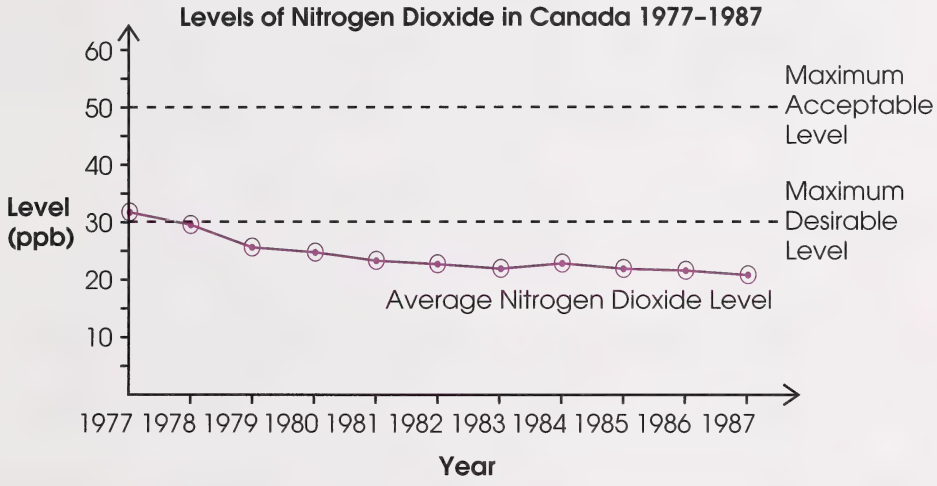
13. How does the Alberta Waste Management Plant dispose of inorganic compounds like acids and bases?

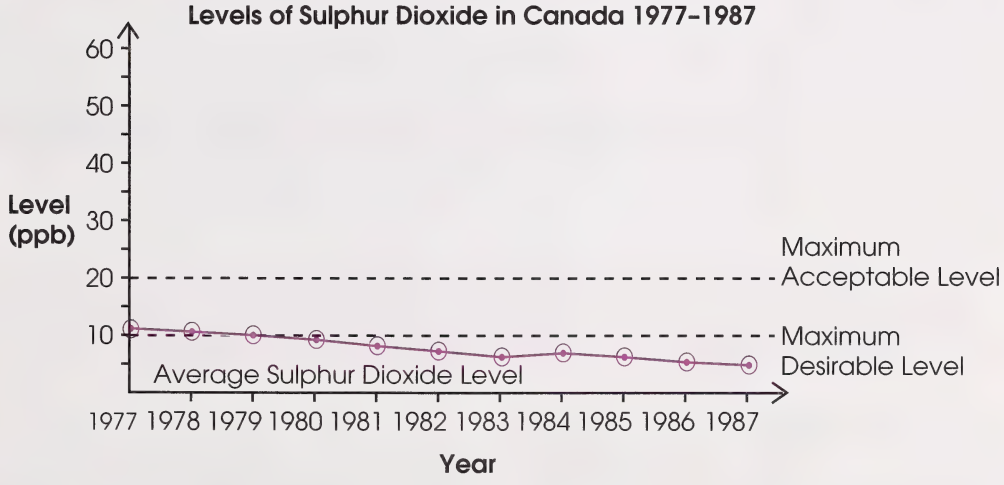
Check your answers by turning to the Appendix, Section 3: Activity 2.

End of Part B

The Alberta Hazardous Waste Management Plant is designed to handle hazardous wastes that are byproducts of production processes or discarded wastes. But what about the hazardous wastes that are released into the atmosphere, lakes, and rivers by industry? What is being done to reduce this type of pollution?

Over the past 20 to 25 years industries have been working to reduce the emissions of sulphur dioxide and nitrogen oxides. The use of scrubbers in fossil fuel burning plants and improved methods for recovering gases from smelters have greatly decreased the amount of sulphur dioxide in the air. The use of catalytic converters on automobiles since 1975 has reduced the amount of nitrogen dioxide produced by vehicles. The following graphs show the trend in the average level in parts per billion of atmospheric nitrogen dioxide and sulphur dioxide in Canada.





14. What trend do you see in the emissions of nitrogen dioxide and sulphur dioxide in the ten-year period from 1977 to 1987?

Check your answers by turning to the Appendix, Section 3: Activity 2.

In addition, industries have been searching for alternatives to PCBs, CFCs, and pesticides. No PCBs have been produced in North American since 1977. However, much of the electrical equipment (transformers) in place contain PCBs. Large amounts of PCBs already lie buried in landfills and could pose problems if they should leak into the surrounding soil.

Industry is searching for substitutes for CFCs as well. Many of these substitutes have fewer chlorine and fluorine atoms in the molecule. The result is that these molecules will break down before reaching the upper atmosphere where they would affect the ozone layer. Many paper-producing companies are replacing the chlorine bleach with hydrogen peroxide and chlorine dioxide. The use of these bleaching agents will greatly reduce the productions of dioxins and furans. In addition some companies are producing unbleached paper for use in certain applications.

Detergents, as well, have been made phosphate-free in recent years. Phosphates cause excessive growth of algae in lakes thereby reducing the oxygen content. The process of eutrophication can be greatly reduced if phosphates are eliminated. There has been some controversy over the benefit of phosphate-free detergents. In order to get the same results, more of a phosphate-free detergent is required. Studies now are showing that other chemicals present in detergents are causing more harm because of the increased amount required.

Industries have also reduced the amount of lead and mercury in the environment. Lead has been eliminated from use in gasoline, and mercury has been replaced in batteries and seed treatment.

15. What efforts have been made by industries to reduce emissions of hazardous substances? Complete the following chart by filling in the appropriate spaces.

Substance Name	Method Used to Reduce Hazard
sulphur dioxides/nitrogen oxides	
CFCs	
PCBs	
dioxins	
pulp and paper effluent	
pesticides	
phosphates in detergent	
heavy metals (mercury and lead)	

Check your answers by turning to the Appendix, Section 3: Activity 2.

Among the most persistent and troublesome of the pollutants previously listed are chemical pesticides. The primary reason for this is that they are so widely used. Of all of the pollutants listed these are also the most difficult to regulate since so little is known of the long-term effects of exposure to pesticides. You have already seen how the use of pesticides such as DDT has been eliminated in response to government legislation, but to do so requires that a pesticide's hazardous potential be known. In many cases it may be too late by the time the hazardous effects are discovered.

One of the solutions which was mentioned in your reading was the concept of genetically engineering a plant to produce its own pesticide. This plan of action is found in nature already and so is deemed to be relatively safe compared to the alternative. The same solution, genetic engineering, has been proposed in order to modify bacteria to enable them to literally eat plastic and excrete simpler compounds.

16. Serious objections have emerged in response to the proposal to genetically engineer bacteria. Explain why it may not be a good idea to produce genetically engineered bacteria.

Check your answers by turning to the Appendix, Section 3: Activity 2.

Investigation: Exploring Alternatives to Chemical Insecticides

Visions

Genetic engineering aside, there are many possibilities for reducing the use of chemical pesticides. Carefully read Activity 6.2, Exploring Alternatives to Chemical Insecticides, which begins on page 211 of your text.

17. Complete the planning and procedure section for this activity. Be sure to make your report as concise and complete as possible.

Check your answers by turning to the Appendix, Section 3: Activity 2.

Millions of litres of herbicides and pesticides are used each year in Canada. Disposal of empty herbicide and pesticide containers have caused a good deal of concern for environmentalists. The following article shows how industry has attempted to solve this problem.

Throughout your life you will have to make decisions about whether or not to do certain tasks or use certain products. Your decision will be based on your perception of the risks involved and the benefits of the task or product.

In Science 20 you completed a risk-benefit analysis based on an article about mercury, as well as a number of other situations. Now, you will do another analysis based on the following article.

Science Skills
- ☐ A. Initiating
- ☐ B. Collecting
- ☐ C. Organizing
- ☑ D. Analysing
- ☑ E. Synthesizing
- ☑ F. Evaluating

18. Read the following article, "*Recycling leads to fenceposts.*" Make a two-column table, listing the benefits you perceive in one column, and the risks you perceive in the other column.

Recycling leads to fenceposts[1]

Pesticide holders put to new use

Dow Jones Service

EDMONTON – A Canadian company has developed a fencepost made of high-density plastic from recycled farm pesticide containers. "They will last for generations," said Harvey Jaehn, president of **Superwood Western Ltd.** of Edmonton.

Although it isn't possible to wash out all the pesticide that has leached into the plastic, the small chemical residue in the posts poses no health threat, according to the University of Guelph toxicology department.

Superwood Western recently completed a test run of 10,000 posts that it sold to the Alberta government for $43,000. It expects to produce 175,000 to 200,000 posts annually after they hit the market this fall.

The plastic "Agriplast" posts will cost about 10 to 20 per cent more than conventional wooden posts, but Mr. Jaehn said buyers will be attracted by their durability.

Discarded chemical containers were a fixture of farmyards and roadside ditches until the early 1980s, when environmental concerns prompted the industry to launch a recycling program.

Now roughly 80 per cent of all containers sold in Western Canada are dropped off at more than 500 collection sites across the prairies, according to industry figures.

19. In your opinion, based on your list of benefits and risks, do you think that these fenceposts are beneficial or are good to use? Explain.

Check your answers by turning to the Appendix, Section 3: Activity 2.

In this activity you have analysed some solutions to the pollution problem brought forward by industry. In the next activity you will consider some things which you as an individual can do to help reduce pollution.

[1] Reprinted by permission of *The Globe and Mail*, ©1992 Dow Jones & Company, Inc. All Rights Reserved Worldwide.

Activity 3: Making a Difference

You and your friend stop at a local convenience store and purchase a few chocolate bars. Having just finished his chocolate bar your friend tosses the wrapper towards the nearest garbage can and misses. With a shrug he dismisses the episode with, "Oh well. It's just one wrapper. It won't make any difference." If just 1% of the population of Canada (about 27 million) were to take the same attitude, think what a problem would result! Does this attitude seem to be growing more prevalent? Is this because people like your friend believe that they can't possibly make a difference? Can **you** as an individual make a difference?

Carefully read Individuals Can Make a Difference on page 219 of your textbook.

Visions

1. A local company is engaged in an activity that you know is detrimental to the environment. What activities would be effective in convincing the company to change the way in which it conducts its business?

Check your answers by turning to the Appendix, Section 3: Activity 3.

Investigation: Formulating a Personal Action Plan

Visions

The question has been put very concisely. What can you, as an individual, do to decrease your impact on the environment? Carefully read Activity 6.4, Formulating a Personal Action Plan, which is on page 219 of *Visions 3*.

2. Carefully follow the instructions in the Procedure and Analysis and Interpretation. If you do not have classmates, summarize your findings in a concise written report.

Check your answers by turning to the Appendix, Section 3: Activity 3.

The following information shows one way in which you as an individual can make a difference in the amount of hazardous waste that enters the environment and reduce the risk to yourself as well. Read the information and answer the question that follows.

The use of the herbicide 2,4-D, in both farm and lawn week sprays, was first introduced in 1946. Since then it has been discovered there are low levels of dioxins present as contaminants in 2,4-D. This product has been re-evaluated as a weed control chemical. Re-evaluation has shown that evidence is inconclusive regarding the relation between use of 2,4-D and the formation of Non-Hodgekin's Lymphoma (a form of cancer) in humans. Some studies show no relationship between 2,4-D and other forms of cancers, while other studies indicate there is a relationship between excessive applications (more than four applications per year) and malignant lymphoma in dogs. Continued study is recommended.

You, or someone you know, may be using 2,4-D for farm or lawn application. Check the label of a weed control product used.

3. The re-evaluation indicates there may be some risk in the use of the herbicide, 2,4-D. If you were applying this herbicide, how could you reduce the risk involved both to the environment and to yourself?

Check your answers by turning to the Appendix, Section 3: Activity 3.

Garbage disposal has become a serious problem for many major cities in the industrialized world. Tonnes of garbage such as plastic containers, metal cans, paper containers, and plastic wrap are disposed of daily. Landfills are overflowing and cities must search for new sites or find different ways to dispose of garbage. Rural areas are not willing to accept the large landfills that are necessary to accommodate the increasing amounts of garbage.

Sewage sludge is another problem with which cities must contend. With increasing populations, cities are finding the amount of sewage sludge (the solids remaining after sewage is treated and the effluent is pumped into a river) is increasing. Where and how to dispose of these solids has become a serious problem.

The following activity will make you more aware of the problems involved with sewage disposal and what you as an individual can do to help.

PATHWAYS

If you have access to the video titled *After the Flush, Part 1 and Part 2*, Alberta Education, ACCESS Network, 1993, do Part A. If you cannot obtain the video, do Part B.

Part A

Watch the video, *After the Flush, Part 1 and Part 2* and answer the questions that follow. This video may be obtained through your school or local library from ACCESS Network or it may be purchased from the Learning Resources Distributing Centre.

4. In the video it is suggested to just flush the sewage further away by making a longer sewer disposal pipe. Why doesn't flushing further make a difference?

5. According to the video, how is sewage presently cleaned before the sludge is produced?

6. What material other than oil could end up in sewers?

7. List the four options to dispose of sewage sludge mentioned in the video.

8. Give two benefits and two risks or problems for each option. Make a chart to organize your information.

9. Which option would you choose? Explain why.

Check your answers by turning to the Appendix, Section 3: Activity 3.

End of Part A

Part B

10. Research the topic of sewage treatment by large urban centres and write a report on how the sewage is treated, what is done with the resulting sludge, and the environmental effects of this type of treatment.

Check your answers by turning to the Appendix, Section 3: Activity 3.

End of Part B

In this activity you have established that individuals can cooperate by reusing and recycling products or reducing the use of products. The level of success of recycling programs depends on you. Changes in environmental impact of pollutants depends on choices you make in the products you consume.

Follow-up Activities

If you had difficulties understanding the concepts in the activities, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

Extra Help

Visions

For a summary of the ideas covered in this module, carefully read the Summary of Chapter 6 on pages 220 to 223 of your textbook.

1. Answer textbook questions 11 and 12 from the Know section on page 223 of your textbook.

2. Answer textbook questions 3, 4, and 6 from the Think section on page 224 of your textbook.

3. Answer textbook question 3 from the Decide section on page 224 of your textbook.

Check your answers by turning to the Appendix, Section 3: Extra Help.

Enrichment

Do at least **one** of the following.

Visions

1. Do Textbook question 3 and 6 from the Think section found on page 224 of *Visions 3*.

2. Do Textbook question 2 from the Projects section found on page 225 of your textbook.

3. Some industries are developing genetically engineered crop plants that are resistant to certain herbicides. The herbicides would then kill the weeds without harming the crop plants. Research plant genetic engineering in general and write a short report on your findings.

4. Research the search for a new landfill site by the City of Edmonton in the spring of 1991 and fall of 1992. Write a report on the search, the reaction of the communities involved, and the end result of the search. You will have to seek out articles from back issues of *The Edmonton Journal, Alberta Report*, or *Maclean's* magazine on microfiche or CD-ROM disks. The CD-ROM disk *Canada News* (which may be available in your local library) should have some information. You may find articles as late as March 1994 useful.

Check your answers by turning to the Appendix, Section 3: Enrichment.

Conclusion

Remember the "technological fix"? Isn't developing a new substance to replace CFCs, or a new way of controlling pests through genetics or biology, just another form of technological fix? From your studies in the preceding section, you should have gained an awareness of the perils inherent in the technological fix approach and hopefully an appreciation of what you as an individual can do to help alleviate the problems linked to the use of organic compounds.

Assignment Booklet

ASSIGNMENT

Turn to your Assignment Booklet and do the assignment for Section 3.

MODULE SUMMARY

Every day new organic compounds are being isolated or synthesized. With the discovery and creation of those new compounds comes the desire to utilize those compounds. As you have seen in this module, the use of organic compounds has both advantages and disadvantages. One question which society will be struggling with for a long time is whether or not the advantages outweigh the disadvantages. The answer to that question ultimately depends on the amount of risk society finds acceptable.

Appendix

Glossary

Suggested Answers

Glossary

amide: an organic compound that contains the amide functional group

amine: an organic compound which contains the amine functional group

benzene: a ring of six carbon atoms which contains three double bonds spaced evenly

functional group: an atom, a group of atoms, or a special bond arrangement that gives a compound its physical and chemical properties

isomer: a compound that has the same molecular formula as another compound but a different molecular structure

monomer: a molecule that can be linked to an identical molecule to form a long chain

polymer: a large organic molecule formed by the linking of a large number of smaller, identical molecules

saponification: the production of soaps from the breakdown of esters

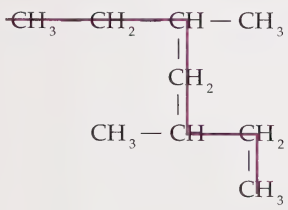
Volatile Organic Carbons (VOCs): organic compounds that vaporize easily or have a low vaporization point

Suggested Answers

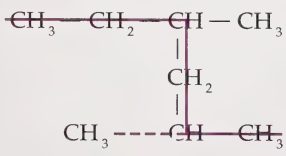
Section 1: Activity 1

1. a. II b. I, III, and IV c. IV

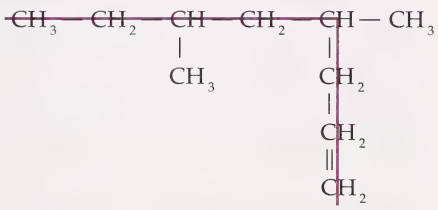
2. a. heptane



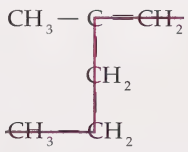
b. hexane



c. octene

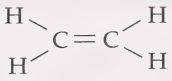


d. pentene



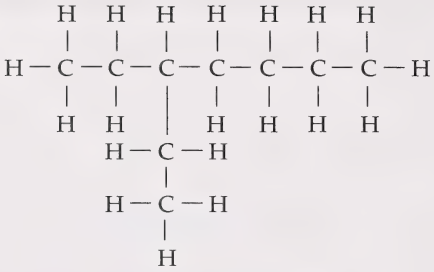
Note: In question 2.b. the line for the longest chain may also be drawn to the left for the last CH_3 as indicated by the dotted line.

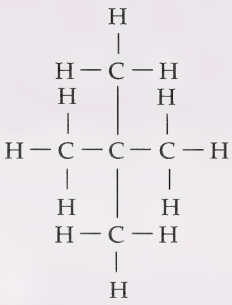
3. a. 2-pentene

b. 

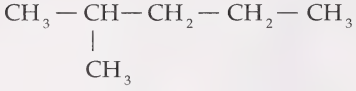
c. 2-methyl-2-butene

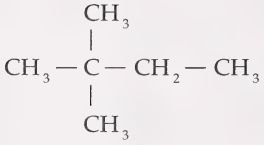
d. 2-pentyne

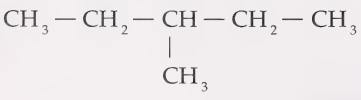
e. 

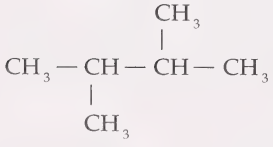
f. 

4. $CH_3-CH_2-CH_2-CH_2-CH_2-CH_3$ hexane

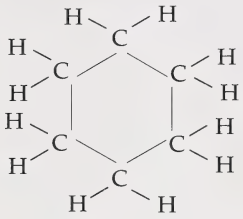

2-methylpentane


2,2-dimethylbutane


3-methylpentane


2,3-dimethylbutane

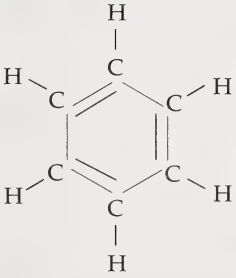
5. structural model



molecular formula

C_6H_{12}

6.



Benzene would have no isomers because they would just look like rotations of the original structure.

7. You must remove six hydrogen atoms from cyclohexane to form benzene. Each double bond forms from the removal of two hydrogens.

Section 1: Activity 2

1. The suffix *-ol* is added to the end of the name of the longest carbon chain to indicate that the molecule is an alcohol.

2. a. 2-propanol b. ethanol c. 2-butanol d. 1-propanol

3. The compounds that are isomers are 2-propanol and 1-propanol (a. and d.).

4. a. The suffix *-ol* in the name tells you that the substance is an alcohol.

   b. The hydroxyl group, — OH, in the structure tells you that the substance is an alcohol.

5. The condensed structural diagrams of the alcohols are shown here.

   a. $CH_3 - OH$

   b. $CH_3 - CH_2 - OH$

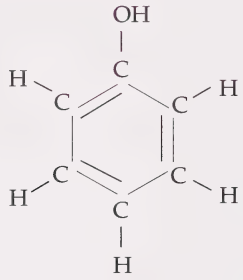
   c. $CH_3 - CH_2 - CH_2 - OH$

   d. $CH_3 - \underset{\displaystyle OH}{\underset{|}{CH}} - CH_3$

   e. $CH_3 - \underset{\displaystyle OH}{\underset{|}{CH}} - CH_2 - CH_3$

   f. $CH_3 - CH_2 - CH_2 - CH_2 - CH_2 - OH$

6. a.



b. Compounds containing a benzene ring have an odour associated with them, so phenol would be no different.

7. Methanol and ethanol are used as solvents in many industries and ethanol is sold as a consumable alcohol.

8. • Using ethanol would result in reduced use of non-renewable fossil fuels.

   • Ethanol can be generated from surplus agriculture crops and waste vegetable matter and so is essentially renewable.

9. a. The *-al* suffix in the name tells you that the structure is an aldehyde.

   b. The functional group $-\overset{\overset{O}{\|}}{C}-H$ on one end of the structure tells you that the substance is an aldehyde.

10. a. The *-one* ending on the name tells you that the substance is a ketone.

    b. The carbonyl group, C = O, in the inside of the structure tells you that the substance is a ketone.

11. Ketones differ from aldehydes only by the position of the carbonyl functional group on the hydrocarbon chain. The ketone carbonyl group is somewhere in the inside of the structure with carbon atoms on both sides. The carbonyl group is at one end of the structure in an aldehyde.

12. The condensed structural diagrams of the various aldehydes are as follows:

    a. $H-\overset{\overset{O}{\|}}{C}-H$

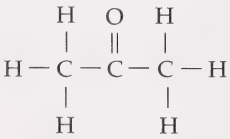
    b. $CH_3-\overset{\overset{O}{\|}}{C}-H$

    c. $CH_3-CH_2-\overset{\overset{O}{\|}}{C}-H$

    d. $CH_3-CH_2-CH_2-\overset{\overset{O}{\|}}{C}-H$

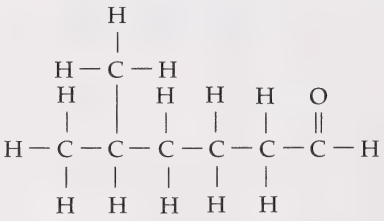
13. a. 3-pentanone

    b.



    c. propanal

    d.



Note: In the answer to question 13.d., since there is a carbonyl group, start counting the carbon atoms from the right. Thus the methyl group (CH_3) is on carbon number five.

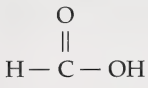
14. Methanal, or as it is more often called, formaldehyde, is one gas thought to be responsible for making people ill. This gas can be released in small quantities for years after a building is built.

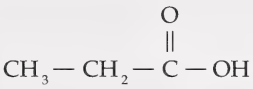
15. a. The *-oic acid* ending on the name tells you that the substance is a carboxylic acid.

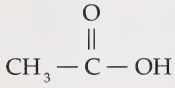
    b. The — COOH functional group in the structure tells you that the substance is a carboxylic acid.

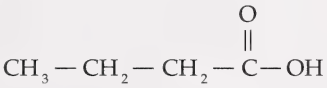
16. Carboxylic acids contain the carbonyl, C = O, and hydroxyl, — OH, functional groups.

17. The condensed structural diagrams for the first four carboxylic acids are as follows:

    a.
    

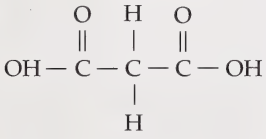
    c.
    

    b.
    

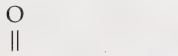
    d.
    

18. Both citric acid and lactic acid are found in the human body, typically within muscles.

19. This molecule is called pentanoic acid in the IUPAC system.

20.


21. a. The *-oate* ending on the name tells you that the substance is an ester.

    b. The
    
    functional group in the structure, with an alkyl (carbon) group attached to the oxygen, indicates that the substance is an ester.

22. Esters differ from carboxylic acids in that the hydrogen atom from the hydroxyl group is replaced by a hydrocarbon branch. Ester functional groups are inside a structure; carboxylic acid functional groups are on the end of a structure.

23. When an ester is formed by the reaction of an alcohol and a carboxylic acid, water is removed.

24. a. 2-butyl ethanoate (isobutyl acetate)
    b. ethyl ethanoate (ethyl acetate)
    c. butyl ethanoate (butyl acetate)
    d. ethyl butanoate (ethyl butyrate)

    Note: The common name is in brackets.

25. This ester would be called octyl ethanoate.

26. a. The prefix (*fluoro-*, *chloro-*, *bromo-*, or *iodo-*) in the name tells you that the substance is an organic halide.

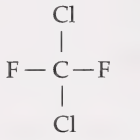
    b. The F, Cl, Br, or I atoms in the structure indicate that the substance is an organic halide.

27. The most common halogenated hydrocarbon in use today is thought to be polyvinyl chloride.

28. Tetrachloromethane, $CCl_{4(l)}$ has been found to be carcinogenic; thus, its use has been discontinued.

29. When there is more than one halogen involved, organic halides are named by giving the names of the halogens in alphabetical order along with the prefix *di*, *tri*, or *tetra* to indicate the number of halogens present.

30. a.



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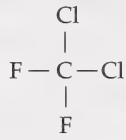
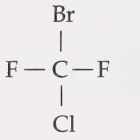


b.



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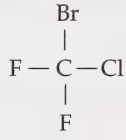
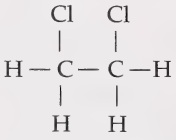
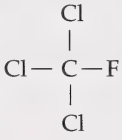


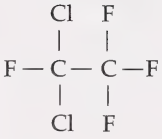
c.



d.

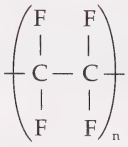


31.



Section 1: Activity 3

1.



2. The polymer that holds cellulose fibres together in wood is called lignin.

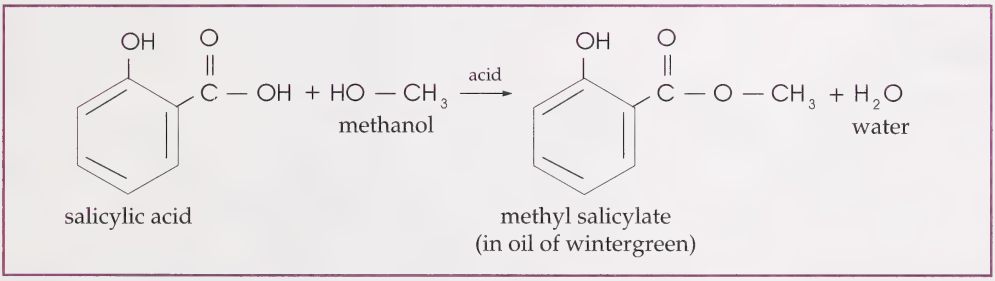
3. Chemical conversion of wood to wood pulp removes a large part of the lignin, which is brown and causes paper to yellow with age.

4. The cellulose fibres must be mechanically beaten to increase flexibility and surface area thus increasing interfibre bonding and final paper strength.

5.

Substance or Mixture	Aroma
methanol	slight alcohol odour, pungent odour if methanol not pure
mixture of methanol and salicylic acid	slight alcohol odour, pungent odour if alcohol not pure
mixture of methanol and salicylic acid after addition of sulphuric acid	slight alcohol odour, pungent odour if alcohol not pure
mixture of methanol, salicylic acid, and sulphuric acid after heating	has a wintergreen aroma

6. **Textbook question 1:**



The product formed is methyl salicylate (oil of wintergreen) which is an ester used in making perfumes, candy, and medicines.

Textbook question 2: The reaction is evidenced by the distinctive odour of wintergreen. The solution may become turbid or somewhat milky as well.

Textbook question 3: The sulphuric acid acts as a catalyst.

7. See the answers in the chart in question 5 of Part A of this investigation.

8. See the answers to question 6 in Part A of this investigation.

9. Water alone would not remove the stains because the oily dirt does not readily dissolve in water.

10. To clean clothes, detergent or soap must be added to the water.

11. The observations from the investigation should be similar to the following:

- Initially, the $NaOH_{(aq)}$ was a clear, odourless solution and the fat was a slippery, white solid.
- Upon mixing the fat and $NaOH_{(aq)}$, the solution became creamy in appearance.
- After 10 min, the solution started to thicken. It was poured into the milk carton mold. The solution no longer had a greasy feeling, but was still slippery.
- After 24 h, the solution had solidified. The solid had a slippery feel to it. When mixed with water and rubbed, the solid produced some bubbles, just like bar soap.

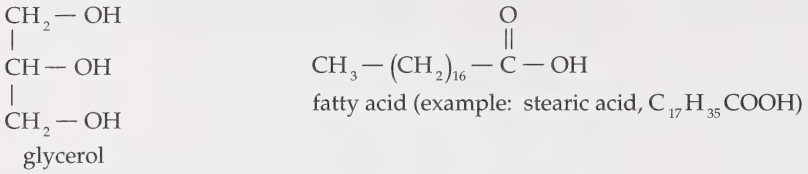
12. a. The soap changed from a liquid solution to a solid, and the greasy feeling of the fat largely disappeared.

    b. The slippery nature of the soap is largely due to the basic nature of the soap—bases feel slippery.

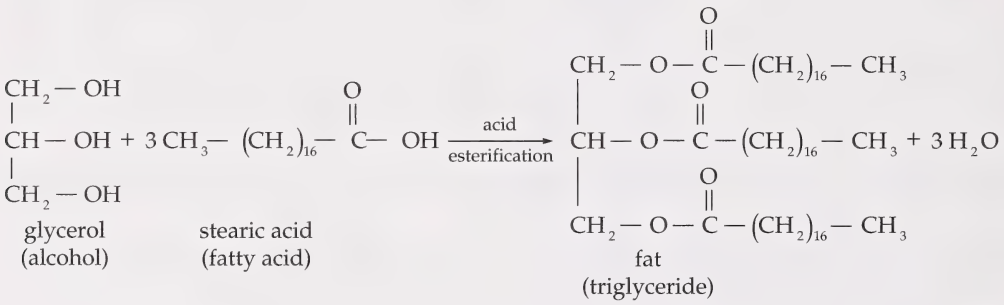
13. "Ring-around-the-collar" does not easily dissolve in water because water is a polar molecule and the collar stain is made up of nonpolar molecules. Nonpolar molecules are not attracted very well to polar molecules.

14. Fats or oils are used to make soap.

15. Fats or oils are esters, made up of glycerol (1,2,3-trihydroxypropane) and three fatty acids (carboxylic acids).

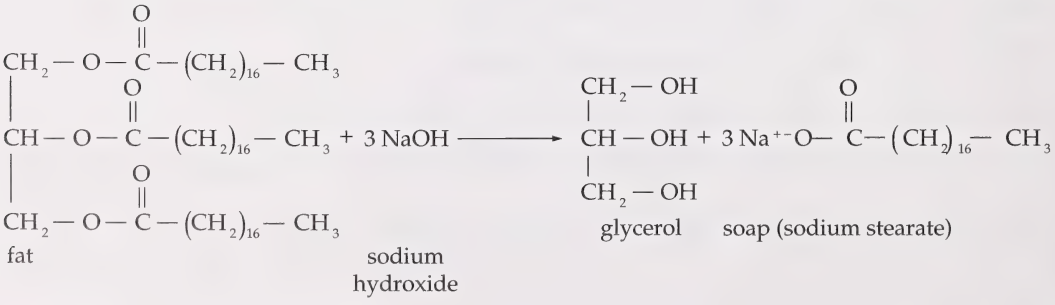


The reaction between the glycerol and a fatty acid (stearic acid) is as follows.

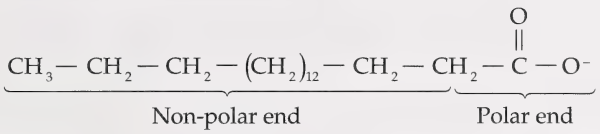


16. Soap is made by reacting fat molecules with a strong base, sodium hydroxide, in solution. The reaction, saponification, is essentially the reverse of esterification.

    The ester linkage is broken between the fat molecules. The soap is an ionic combination of the fatty acid ion and the sodium ions from the base.



17. A soap molecule is able to dissolve grease stains because of its structural make-up. One end of the soap molecule is polar, the other non-polar.

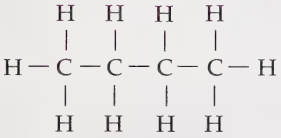


The polar end of the soap molecule allows it to dissolve in water (water molecules are polar and attract polar substances). The non-polar end seeks a non-polar environment, the grease. When enough soap molecules have been attracted to the grease (non-polar ends to non-polar molecules), the outer polar ends allow the grease to be attracted by the water (polar to polar) as small globules and get washed away.

Section 1: Follow-up Activities

Extra Help

1. a.



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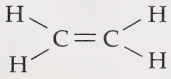
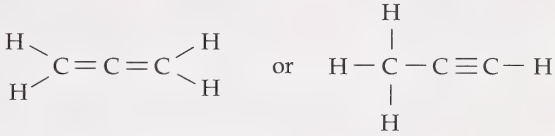


c.

d.



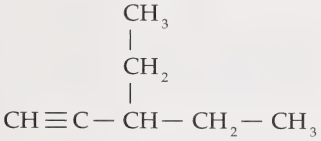
2. a. 2,3-dimethylbutane

b. 2-methyl-2-pentene

c. 3-ethyl-4-methyl-1-hexyne

d. 2,2,4,4-tetramethyl-1-pentene

3. a.



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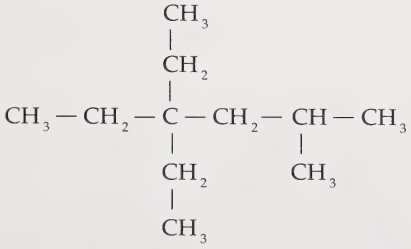
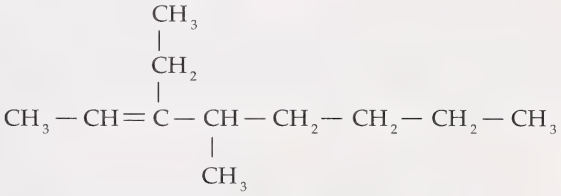
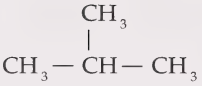


c.



4. $CH_3 — CH_2 — CH_2 — CH_3$ and



5. You could use your sense of smell. Most molecules that contain a benzene ring have an odour.

6. A functional group is any group of atoms that gives a characteristic chemical reactivity to a molecule which contains that group.

7. a) Alcohols have a distinct, often pleasant odour.

   b) Aldehydes are formed from alcohols by dehydrogenation.

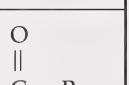
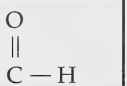
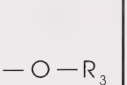
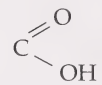
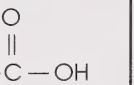
   c) Ketones are excellent solvents and have distinctive odours.

   d) Carboxylic acids are weak organic acids.

   e) Esters have very pleasant odours and contribute to the flavour of most fruits.

   f) Halogenated hydrocarbons are either toxic or ecologically damaging.

8.

Class of Organic Compounds	Functional Group	Name or Suffix Used to Indicate Presence	General Formula
alcohols	— OH (hydroxyl)	-ol	R — OH
ketones	C = O carbonyl	-one	
aldehydes	C = O carbonyl	-al	
ester		-yl for R_2 -oate for R_1	
organic halides	fluorine chlorine bromine iodine	use name for longest carbon chain and add name for each halogen -chloro -bromo -fluoro -iodo	R — X
carboxylic acids	 carboxyl	-oic acid	

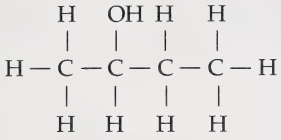
9. **Textbook question 3:** a. propanoic acid b. 2-hexanone c. methyl ethanoate d. 2-hexanol

   Textbook question 4: The polymer is cellulose that is made of the monomer glucose.

10. Polymers are formed of repeating subunits called monomers.

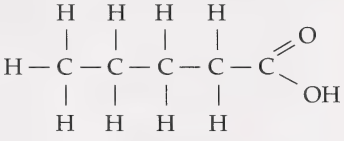
11. **Textbook question 1:**

a.



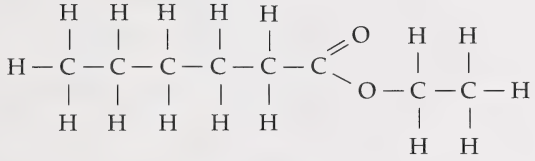
2-butanol

b.



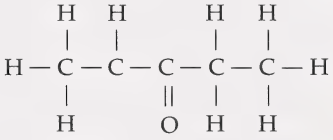
pentanoic acid

c.



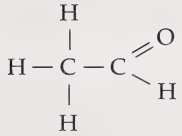
ethylhexanoate

d.



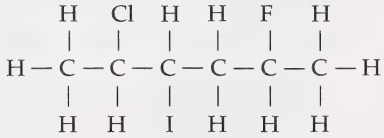
3-pentanone

e.



ethanal

f.



2-chloro-3-iodo-5-fluorohexane

Enrichment

1. **Textbook question 2:** Answers will vary, but an acceptable answer should include the idea that many of the articles taken for granted today would not exist. These items could include sports equipment, building materials, plastic wrap, and so on. Mention five different types of things that you use and that influence your lifestyle.

2. Answers will vary but should include that ethanol is prepared by the fermentation of sugars from fruit or grain. Ethanol is used for the manufacture of plastics, synthetic rubbers, synthetic fibres, and other products. If the use of ethanol as a fuel is mentioned, it should be noted that converting all of the grain grown in Canada each year into ethanol would supply less than half of the fuel needed to supply this country's demand for fuel.

3. The following are some points that you may have included in your report. Soap has been used for millennia with the vary earliest reference to soap being found on Mesopotamian clay tablets from about 3000 B.C. Another reference to soap as a cleansing agent and antiseptic appeared in the writings of Galen, a Greek physician from about 200 A.D. In the Middle Ages important centres of soapmaking developed in Spain, France, and England, but manufacturing was on a relatively crude level until about the 1700s when it became possible to make soap according to a formula, which lead to exact and predictable results. Today the soap industry is a multibillion dollar industry.

4. Charles Goodyear was an American inventor in the early 1800s who developed the vulcanization of rubber. He had already spent time in prison, for not paying his debts, when he made an accidental discovery. Finding natural rubber to be sticky when hot and brittle when cold he began to search for an improved product. In 1839 he accidentally found that a heated mixture of rubber and sulphur gave improved strength and elasticity. This process of treating natural or synthetic rubber or similar plastic material chemically to give it improved properties such as elasticity, strength and stability is called vulcanization. Goodyear obtained a U.S. patent in 1844, but by then another inventor Thomas Hancock had studied Goodyear's samples and received a British patent. Goodyear tried unsuccessfully to market his product in England and France but several other competitors had beaten him to it and the market was just not there. Goodyear spent most of the rest of his life in debtors' prisons and ultimately died still in debt. Goodyear had nothing whatsoever to do with the company named after him. The term *vulcanization* was given by someone else for the process discovered by Goodyear.

5. The cosmetic industry relies heavily on ideas developed by chemists. To produce a cosmetic, the nature of skin must be understood. Skin has two general regions. The dermis functions to protect the body. The epidermis contains the sweat glands, blood capillaries, and hair follicles. The epidermis has a continuing cycle of cell generation to replace cells that are lost from the surface. To reduce cell loss and keep the epidermis soft and supple (and thereby more resistant to infection), water is supplied by the sweat glands in the dermis. The moisture is kept in by an oily layer produced by sebaceous glands surrounding the hair follicles. Dehydration of the epidermis creates cracking of the epidermis and allows infection to invade the skin.

   In creating a lipstick, the lack of sweat glands in the lips and the presence of only a few sebaceous glands has to be recognized. This condition leaves the lips susceptible to chapping and infection. Therefore a lipstick has to provide moisture and prevent dehydration. Cosmetic chemists employ two types of dyes to do this: eosine dyes that are water-soluble and lake dyes that are oil-soluble.

   The dyes are mixed in oil to create a paste. Carnuba wax is used to give form to the paste. Carnuba wax also provides a medium for transferring the dyes as the wax will hold its form until pressure is applied. At that point it melts and then resolidifies after the pressure is removed—hence the lipstick application. To improve binding of the paste to the carnuba wax, beeswax is added. Antioxidants are added to prevent the oils from going rancid and causing infection. Finally perfume is added to the mixture to flavour and scent the product.

   The production of lipstick must keep the nature of the lips in mind. The appropriate organic molecules and chemistry must be used to aid the lips in reducing dehydration and infection.

Section 2: Activity 1

1. Persistent pesticides are pescticides that break down very slowly and thereby accumulate in lake water and soils.

2. Figure 6.14 indicates that as you progress up the food chain there is an increasing concentration of pesticides found in organisms.

3. Step 4. Organophosphates and carbamates inhibit the action of cholinesterase and result in almost continual stimulation of a nerve leading to convulsions and death.

4. Carbamates and organophosphates quickly break down into smaller less toxic fragments in a matter of days or a few weeks. DDT, on the other hand, may take several years to break down.

5. In the manufacturing of the herbicides there is always at least trace amounts of byproducts that appear. Those byproducts may be toxic to humans. When herbicides are sprayed onto plants those toxic byproducts will be released into the environment as well. In the case of Agent Orange, trace amounts of polychlorinated dibenzo-p-dioxins (PCDD), or simply dioxins, caused the birth defects.

6.

Substance Name	Source	Biological Hazard
mercury	effluent from industrial plants, mercury amalgam fillings in dental work, lamps	• loss of equilibrium • loss of feeling • brain damage
dioxins and furans	toxic contaminants in PBCs produced by exposure to heat and oxygen	• birth defects • degree of harm varies with species
lead	combustion of leaded gasoline until recently, paint, solder in pipes, motor oils, explosives	• anemia • loss of kidney function • brain damage

7. The effect of TCDD varies widely from species to species. TCDD and other dioxins have been proved to cause only one disease in humans—chloracne, a skin disorder—although most scientists agree that it is probably capable of much more damage. In general, dioxin's effects on laboratory animals are so lethal that some scientists rank it among the most poisonous substances known. Testing is not done on humans and so it is not possible to say exactly what effects there will be.

8. They are all substances that are the direct result of humankind trying to control and modify the environment.

9. Mercury and lead are still in use because they are materials that are extremely useful. The fact that they are also highly toxic is a reflection of society's willingness to sometimes trade risks for benefits.

10. According to the video, toxic wastes cripple wildlife, pollute waters, corrupt air, contaminate land, and poison human bodies.

11. Toxicity is the ability of a chemical substance to interact with the chemistry of living things so as to impair their function.

12. Toxic substances fall into the following general classifications. Your answer could include any three of those given.

Corrosives	• destroy living tissue; e.g., acids, bases, and oxidants such as laundry products
Metabolics	• interfere with vital body functions; e.g., carbon monoxide, lead, mercury, arsenic, and cyanides
Neurotoxins	• interfere with nerve impulses so as to cause overstimulated nerves or produce irregular heart rhythm resulting in convulsions and death; e.g., nicotine, atropine, and dioxins

Mutagenics	• are capable of altering genes; e.g., sodium nitrate
Teratogenics	• act directly on human reproductivity; e.g., nicotine and various other chemicals in cigarette smoke as well as radiation
Carcinogenics	• directly cause cancer; e.g., nicotine

13. Individuals pollute significant amounts through the multiplier effect. Millions of the same item are discarded by individuals causing a pollution problem when all of these items are dumped together.

14. One of the things that industry is doing to reduce the pollution of the air is to collect all vapours when transferring volatile products.

15. Pollutants that individuals put into the environment include oven cleaners, leftover prescription drugs, nail polish, nail polish remover, oil, and antifreeze.

16. As a consumer of these products, you can take any leftover amounts in their containers to collection sites in your city or area for disposal at the Hazardous Waste Management Plant in Swan Hills, Alberta.

17. The Hazardous Waste Management Plant takes the most toxic chemicals produced and reduces them to common elements, thereby eliminating these toxic chemicals from landfills and backyards.

18. Individuals can reduce the pollution of the environment by using as few disposable products as possible and recycling those that they do use where possible.

Section 2: Activity 2

1. Ozone and peroxyacetyl nitrate result from the interaction of VOCs and nitrogen oxides. VOCs are emitted naturally by vegetation, and nitrogen oxides are a natural product of forest fires, lightning, and bacterial decay. Even though emissions of nitrogen oxides caused by humans have been decreased, it is impossible to eliminate their presence in the atmosphere and the resulting production of some ozone and peroxyacetyl nitrates.

2. Turpentine is a volatile organic compound (VOC) and will react with nitrogen oxide in the atmosphere to create toxic ozone and peroxyacetyl nitrate.

3. VOCs remove nitrogen oxide from the atmosphere. Because the nitrogen oxide is no longer present to remove an oxygen atom from ozone there will be a buildup of ozone in the atmosphere. This is indicated in the second diagram by the break in the cycle between ground level ozone and nitrogen oxide.

4. Water at different levels varies in temperature resulting in different amounts of dissolved oxygen as well as different chemical reactions at the different levels.

5. The type of container used is specific to the chemical to be tested for. Some of the compounds to be tested stick to glass and will not remain in solution and will require a polyethyene bottle. Some compounds stick to polyethylene and so require glass bottles. Some substances require special conditions for temperature and acidity and would require different types of bottles.

6. Three methods used to analyse water are as follows:

   - Atomic absorption spectroscopy – used to analyse concentrations of metals in a water sample
   - Inductively coupled plasma – used to detect several different metals in a single water sample
   - Gas-liquid chromatography – used to detect organic compounds

7. Answers will vary but should include the following points:

   - The sample is injected into the instrument and converted to the gas phase.
   - An inert gas is used as a carrier to move the sample through a fine tube which has a film on its inner surface.
   - Compounds are absorbed at different rates in the tube and a graph of retention times for each of the various compounds is printed.
   - Computers are used to automatically store the information from hundreds of samples passed through a gas-liquid chromatography instrument.
   - Gas-liquid chromatography is used for air and water testing, drug testing, and in research laboratories.

8. The biological oxygen demand (BOD) can indicate how polluted a water source is by showing the level of bacteria present.

9. Answers will vary, but your plan should include the following:

   - Water samples from various locations along the river need to be taken to determine if any of the other industrial plants are causing the problem.
   - If the pollution is coming from the landfill, then a decision needs to be made whether to move the landfill or both the landfill and the water intake (assuming the intake is presently near the water treatment plant).
   - The various problems with the relative position of the landfill relative to the water treatment plant and the rest of the town need to be discussed.

   You might contact your town water representative to see how precautions are taken to protect your water supply. If you live on a farm or acreage you might check to see how your well is protected from contaminants.

10. Answers will vary. Your report should mention the major chemicals that may be released into rivers, the effects of thermal pollution, new processes which have been developed to make paper, as well as technological advances such as paper recycling and electronic mail that could reduce the need for paper.

Section 2: Follow-up Activities

Extra Help

1. **Textbook question 5:** Most pesticides are neurotoxins and directly affect the nervous system of the insect in question causing it to malfunction.

   Textbook question 6: The newer organophosphates are safer than DDT in that they break down into non-toxic compounds much faster.

   Textbook question 7: In the production of 2,4,5-T trace amounts of dioxins are created. Dioxins are known to result in birth defects, hence the herbicide has been banned.

2. **Textbook question 2:** Dioxins are created as contaminants during the manufacture of some pesticides, as a product when PCBs are exposed to heat and oxygen, and during the processing of pulp wood with chlorine to make paper.

   Textbook question 3: Mercury is most toxic when it is in organic compounds as a side group to the carbon chain. It can be converted to this form by bacteria in the sediments.

3. **Textbook question 5:** Answers will vary but ideas that should be included are as follows:

   - Technological development requires production of machines that requires raw materials to be removed from the environment and subsequently modified.
   - The removal process involves the use of machines that create toxic byproducts as a result of their operation.
   - The modification process often results in toxic byproducts; often this is only noticed after the fact.

Enrichment

1. In the 1950s a factory manufacturing plastics on Minamata Bay in Japan produced mercury salts as one of its byproducts. The effluent from the factory was discharged into the ocean where bacterial action fixed the mercury into organic form. Biomagnification eventually produced fish that were seriously contaminated with organic mercury. The community of Minamata, which is located on the bay into which the effluent was dumped, derived much of its food from fish and shellfish caught in the bay. Cats feeding on the fatty intestines of cleaned fish showed the first signs of mercury poisoning. Neurological damage caused the cats to "dance" in circles before they died. The pollution was not detected in humans until an alarming increase in the number of birth defects, primarily physical abnormalities, occurred within the community.

   One of the best sources for information on the magnitude of this environmental disaster is a book by W.E. Smith and A.M. Smith entitled *Minamata* published by Holt, Reinhart & Winston, New York, 1975.

2. The overuse of pesticides is a problem because in any pest population there are always a few resistant organisms. Those organisms go on to successfully breed with other disease-resistant organisms and produce offspring which are no longer affected by the pesticide in question. As the use of that pesticide becomes more prevalent, there is a greater amount of resistant organisms produced, eventually rendering the pesticide useless. The greatest use of pesticides is in the agriculture industry and so the greatest risk is faced by farmers.

3. During the 1950s thalidomide was widely used to treat nausea and vomiting during pregnancy. In 1961 the drug was found to result in congenital malformations (birth defects), the most likely being an abnormality in which the arms formed incorrectly or not at all. About 10 000 such children were born worldwide, and because of the drug's extensive use, 5 000 in Germany alone. Thalidomide continues to be used in some countries mainly for relief of leprosy symptoms. It was found in the late 1980s to be effective, in conjunction with cyclosproine, in treating auto-immune reactions for bone-marrow transplants.

Section 3: Activity 1

1. Answers will vary, but a short list would include packaging materials, bottles and containers, textiles, plumbing, flooring, carpets, paints, glues, electrical insulation, automobile parts, electronic cases, video and audiotapes, records and compact discs, pens, razors, toothbrushes, hairsprays, plastic bags, eating utensils, and so on.

2. The total amount of waste buried in landfills in Edmonton and Calgary in 1992 was over 1.2 million t.

3. Assuming one-third was residential garbage, the amount of residential garbage would have been over 400 000 t.

4. Many major cities have had to face the consequence of their landfill filling up and having to search for new sites.

5. Present recycling reduces only 10–20% of the residential wastes. Population growth can increase the volume of waste and nullify the effect of recycling. In addition it is sometimes less expensive to make a new product from raw materials than to recycle the old product or make a new product from recycled material. Often, the only way to reuse the material in the old product is to come up with a different product to be made from it.

6. Unless burned at extremely high temperatures so the combustion is complete, the burning of plastics results in the release of hazardous compounds.

7. Industries are attempting to develop plastics that are biodegradable or that break down on exposure to light.

8. Other problems involving the environment include the following:

    - release of various organic compounds into the atmosphere, lakes, and rivers
    - effluent released from pulp and paper mills
    - accumulative effect of herbicides and pesticides used
    - worldwide release of greenhouse gases into the atmosphere
    - depletion of the ozone layer

Section 3: Activity 2

1. The four *R's* of recycling are reducing, recycling, reusing, and recovering.

2. Not everything can be recycled, so a plant is still required to eliminate certain toxic wastes.

3. The two wastes that the Alberta Waste Management Plant does not handle are radioactive wastes and explosives.

4. To improve the safety of transporting hazardous wastes, these chemicals are placed into sealed containers and then these containers are again put into sealed drums.

5. The ground water is protected by having the effluent from the treatment of hazardous wastes pumped into spaces more than 2000 m below the surface. This is far below the level of any ground water.

6. The largest group of chemicals treated are the organic chemicals.

7. Organic chemicals are put into a combustion chamber and oxidized at high temperature.

8. In order to maintain a clean environment, the air, water, and soil, around the plant are continuously monitored for traces of contaminants.

9. The government has instituted regulations governing the use and handling of hazardous materials. The Alberta Special Waste Management Corporation was set up in 1984 to oversee the collection, transport, and treatment of hazardous wastes in Alberta. In 1987 one of the most advanced hazardous waste treatment plants in the world was opened in Swan Hills, Alberta.

10. The Alberta Hazardous Waste Management Plant does not handle radioactive materials or explosives.

11. Organic wastes are incinerated at extremely high temperatures to produce non-toxic compounds. Liquid wastes are treated by neutralization or precipitation.

12. Ash from the kilns and other solid wastes are treated with stabilizing chemicals and deposited in specially constructed and monitored landfills. Liquid wastes are injected into wells which are far below any aquifers used as sources of water.

13. Acids and bases are neutralized or precipitated. The solid precipitate is then added to other solids and buried in the landfill. Liquids from neutralization are injected into deep wells 2000 m below the surface.

14. The graphs show a decrease in the amount of nitrogen dioxide and sulphur dioxide present in the atmosphere in the ten-year period 1977 to 1987.

15.

Substance Name	Method Used to Reduce Hazard
sulphur dioxides/nitrogen oxides	industrial gas scrubbers and catalytic convertors
CFCs	less efficient but safer replacements used
PCBs	no longer manufactured or used
dioxins	methods and compounds responsible no longer in use, alternatives being investigated
pulp and paper effluent	alternative methods and reduced emissions
pesticides	plants genetically engineered to produce their own pesticides
phosphates in detergent	replaced with other materials
heavy metals (mercury and lead)	alternatives identified to reduce the use of heavy metals (e.g., mercury-free batteries)

16. Once the bacteria is released into the environment there may be no way of controlling its action. Bacteria are highly prone to mutation and there may be a relatively small step from something which attacks the nervous system of insects to something which attacks the nervous system of humans. The release of a potentially lethal bacteria for humans into the environment is something which should be thought over carefully.

17. Answers will vary, but whatever topic you choose your answer should include information regarding each of the four areas mentioned in the Procedure on page 212 of *Visions 3*. A short summary of some of the points follows.

Topic I
Natural predators, parasites, and pathogens (disease-causing organisms) have been used with some success; however, these methods can only control about 100 species of insects pests, out of about 10 000 known species. This method is not very effective in combating fungal, bacterial, nematodal, and viral diseases.

Topics II, III, and IV
Recently, highly sophisticated insect-control measures have involved the release of large amounts of sterile males, the use of sex-attractant pheromones, and the application of physiologically disruptive pest hormones. These methods look promising but are highly species specific, relatively limited in number, relatively expensive, and require a continuous application over large areas to be effective.

18.

Benefits	Risks
The following are benefits: • reduce waste in landfill • produce new, lasting products • reduce consumption of wood products • create employment in a new industry	Pesticide residues pose a possible health hazard.

You may have a slightly different set of benefits and risks.

19. Based on the overwhelming set of benefits compared to risks, it would seem that using recycled plastic posts should be beneficial.

Section 3: Activity 3

1. One method to convince the company may be to refuse to buy their product. Companies often listen to anything that reduces their profitability. You also might try talking to the company about the problem. They may not have perceived it as a problem.

2. Answers will vary for this activity depending on personal preference and location. However, your report could include some of the following points.

Procedure Part 1

- Containers from pesticides, spray paints, furniture polish, and other household chemicals could be taken to a hazardous waste collection site if such a site is available.
- Used oil could be sent for recycling.
- Types of garbage can be separated for disposal—plastic, metal, glass, paper, and so on.
- Send all used prescription and over-the-counter drugs to a collection site rather than disposing of these in the garbage.
- Share a daily paper or read a copy at the local library.
- Walk or ride a bicycle whenever possible.

Procedure Part 2

- You may find garbage disposal sites that are not properly developed or maintained.
- Does your local garbage disposal site have separate areas for metal, wood, paint cans, and other garbage?
- You may find garbage thrown along roadways. Try to get it cleaned up.
- Check with your local council if there is an environmental organization in your area. You may wish to join it.

3. The following are a number of possible ways to reduce the risk of applying 2,4-D or any herbicide.

   - Apply it only if required due to excessive weeds.
   - Follow the application rates given on the label. Do not apply excessive amounts.
   - Wear protective clothing.
   - If concentrated 2,4-D is spilled on skin, rinse contact area immediately with water.
   - Apply herbicide only when winds are light.
   - Prevent excessive drift by setting the spray to larger droplets.
   - Remove and wash protective clothing after use.

4. You must consider the entire planet when disposing of sewage or any garbage. Just because you cannot see a problem doesn't mean it doesn't exist.

5. Sewage and water runoff are collected into large holding tanks where the solids are allowed to settle while oils and light garbage float to the top. The garbage is collected and sent to the landfill while the oil is skimmed off the top. Bacteria is then used to process the organic material.

6. Materials, other than oil, that could end up in the sewers include paints, car antifreeze, and household chemicals.

7. The four options to dispose of sewage sludge mentioned in the video are spreading on farms, composting, heat processing, and irradiation.

8.

Option	Benefit	Risk or Problem
spreading on farms	• valuable for farmers • product could be sold if approached properly • good soil conditioner	• more sludge than local farms can accommodate • contains pathogens (not safe for growing root crops) • high cost due to longer distances that sludge must be trucked • fields must be dry
composting	• uses garbage as well as some of the sludge • clean, sanitized • environmentally good • can be used for reclaiming land	• not all sludge used • must do indoors in northern climates making it expensive • not all pathogens killed • plant will have odours • never tried in northern climates on a large scale
heat processing	• dry, odourless, safe • reduces volume of sludge • soil conditioner	• uses fossil fuels • high cost • not useful as a fertilizer
irradiation	• pathogen-free • soil conditioner • reasonable operating cost • no fossil fuels required • no environmental pollution	• not useful as a fertilizer • expensive to build initially • people have fear of the technology

9. Answers will vary, but your choice should be based on an analysis of the benefits and risks or problems associated with each option. Also consider the rating given for each option given in the video.

10. Answers will vary. Your report should be about one page long and should answer the three questions posed in question 10 depending on what is done in the particular city you chose.

Section 3: Follow-up Activities

Extra Help

1. **Textbook question 11:** Trash is buried in landfills to keep it away from scavengers and to prevent the spread of disease-causing organisms.

   Textbook question 12: Individuals can make a difference by refusing to purchase products which are harmful to the environment or by reducing the amount of trash produced by a combination of recycling and reusing.

2. **Textbook question 3:** Natural insecticides occur in some plants such as tobacco which produces a natural carbomate. Natural insecticides can be employed by tailoring the genes of other plants, to allow them to produce their own natural insecticides.

   Textbook question 4: Ways in which the use of herbicides, pesticides, and fertilizers by homeowners can be reduced are as follows.

   - Educate homeowners to use only the specified amounts.
   - Sell only premixed herbicides and pesticides.
   - Allow only trained professionals to apply herbicides, pesticides, and fertilizers.
   - Educate society regarding a change in attitude on what constitues landscaping. The ideal lawn of uniform-height, bright green grass may very well be an outmoded idea. Landscape architects and environmentalists are suggesting rock gardens, such as those found in Japanese landscapes, or plants natural to the environment surrounding them. It will also require a rethinking on society's part as to what constitutes a "weed."

   Textbook question 6: As waste materials continue to accumulate, a further degradation of the environment will occur. Landfills are being filled to overflowing with materials derived from irreplaceable fossil fuels. Such materials will need to be recovered in the future as fossil fuel stocks decrease. Future generations may suffer from the "throw away" attitude.

3. **Textbook question 3:** Humankind has demonstrated in the recent past a shortsightedness as to its effect on the environment. The advantage to laws regulating the "throw away" attitude is that it would force people to at least think twice about discarding a usable material. It may also be necessary to limit the amount of material which society is allowed to discard as this would then also force people to change the way in which they purchase materials. A large proportion of waste going to landfills is the result of overpackaging of consumer goods.

Enrichment

1. **Textbook question 3:** Many plants contain natural insecticides. Some of these insecticides block metabolic pathways or adversely affect the digestive system of the insects.

   Textbook question 6: The waste that one generation accumulates takes up space, depletes the non-renewable resources, and threatens the environment. The size of the biosphere is stationary but the human population and therefore the amount of garbage is growing exponentially. This threatens the lifestyle of future generations. The responsibility of the present generation is a topic of debate worldwide. However, it is reasonable to expect that future generations would not want to clean up a mess they had not created.

2. An amalgam is an alloy of mercury and one or more other metals, formed by dissolving metals in mercury. Copper, gold, and silver have to be dissolved in a solution of a mercury salt and it has been suggested that bacterial action may be capable of converting mercury salts to organic compounds which contain mercury. The mouth provides an ideal site for bacteria formation and the proximity of amalgams containing mercury salt increases the risk. In addition when people chew, some mercury vaporizes and is absorbed into the blood stream through the lungs. Recently, filling materials made of plastic polymers are becoming more widely used. The newer polymer fillings were once used only in non-stress areas in the front part of the mouth; they are now being utilized in the posterior part of the mouth on the chewing surfaces. Polymer fillings have an advantage over metal fillings because it is possible to match the colour of the filling to that of the surrounding tooth. In addition, they polymer filling can be chemically bonded to tooth structure.

3. Answers will vary but your report should include some of the following points.

   - Plant cell engineering involves the use of plant viruses to insert new genes into plants.
   - Using this technique it is possible to isolate a particular gene, insert it into a single plant cell, and use that cell to grow a complete new plant containing the genetic modification.
   - This technique can be used to produce crop plants with genes for nitrogen fixation, herbicide resistance, and high efficiency photosynthesis.

4. Answers will vary but your report should include some ideas on the following points.

   Search

   - Several communities were approached or actively sought the landfill site. The County of Thorhild which actively sought the landfill site had the most controversy.
   - A substantial amount of money was spent by the City of Edmonton as well as the communities approached.
   - Citizens actively participated in numerous area meetings, the search for information regarding modern landfill disposal sites, as well as the decision-making process in accepting or rejecting the proposal.

   Reaction

   - Communities were divided over the issue with part of the communities reacting negatively, while others were supportive of a landfill locating in their community.
   - Presentation of new information on the landfill did not seem to change people's minds.
   - A risk-benefit report should be included in your report listing the risks and benefits to the community receiving it.

   End Result

   - Citizens actively achieved the result they wanted for their communities; Edmontonians are doing more recycling and reusing than ever before.
   - The present disposal site which originally was though to have a life expectancy of only 3 to 5 years now has a life expectancy of 15 or more years due to recycling and reduced amount of garbage going to the landfill.

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